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THE

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THE PROGRESSIVE FISH-CULTURIST

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FOUR YEARS' PROGRESS IN THE USE OF ARTIFICIALLY CONTROLLED LIGHT TO INDUCE EARLY SPAWNING OF BROOK TROUT

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Concord, New Hampshire

MANY INQUIRIES CONCERNING OUR PROGRESS with the use of artificial light to induce early spawning in brook trout have resulted in the following summary, which, it is hoped, will point the way to better insight into similar projects.

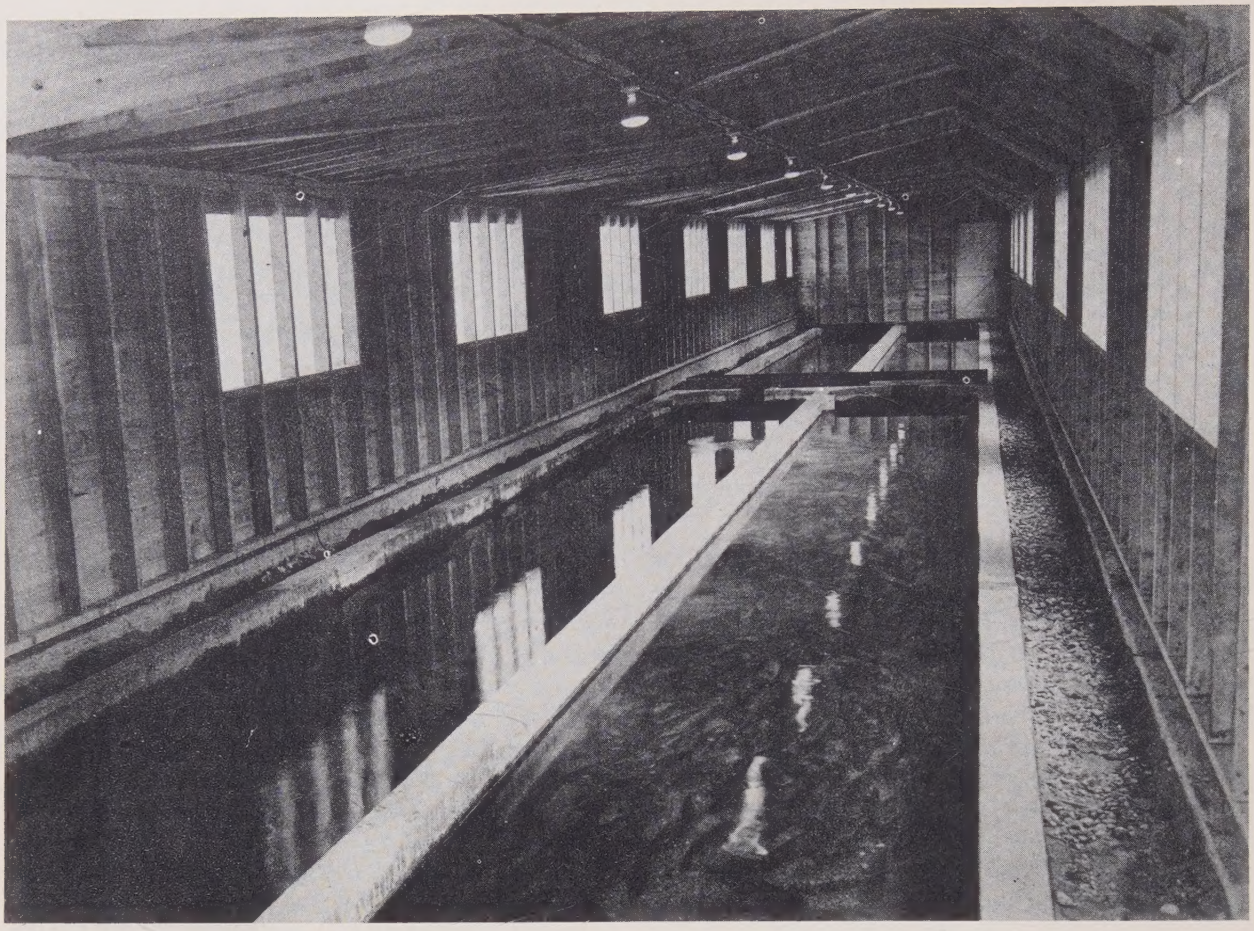
The magnitude of the early spawning program in New Hampshire has been governed by the carrying capacity of our nine hatcheries and rearing stations in relation to the five other species of salmonoid fish that we propagate. The peak spawning activities for brook trout (Salvelinus fontinalis) in this region occur during November; however, since 1951 we have continued a program of collecting eggs from brook trout during August, as a result of the early maturation of gonads induced by modification of light. This has been an important part of our current program to develop an improved strain of trout that will better fit our needs, rather than to rely entirely on stock from commercial trout dealers. Also, there are possible advantages in cultivating eggs that are acclimated to our New Hampshire environment.

The site of this project was established at the New Hampton Hatchery of the New Hampshire Fish and Game Department late in the fall of 1951. At that time our engineer designed a wooden brood house to enclose four pools with dimensions of 5 by 50 feet, these pools being supplied with a constant flow of spring water at the rate of 126 gallons per minute and temperatures not exceeding 43° F. The front section, which has a total of 884 square feet, was designed so that 126 square feet of hinged panels could be opened, allowing daylight to be used during those periods when the project was inactive. All crevices were painted black to minimize reflections of daylight. The rear wall of the building has 676 square feet, of which 154 were allowed for hinged-panel openings in staggered opposition to those on the front wall in order to permit a more even distribution of natural light. The cost of the brood house was approximately $2,658.

Light Intensity and Schedule

A time switch was installed to control 12 overhead 150-watt medium-base reflector flood lamps that supplied the artificial light to induce early spawning activities. The light intensity, expressed in lumens per square foot at water level, was recorded at 40 with all panels closed. The vertical distance from the surface of the water to the light bulb is 8 feet.

The following light schedule is annually initiated on January 15: 1 hour a day in excess of the normal daylight period for the season at 44° latitude for the first week, 2 hours for the second week, etc., until use of 9 hours of artificial light in excess of the normal light period has been reached. The light is then maintained on this schedule for a period of 4 weeks, after which the light is decreased 1 hour



(Courtesy the New Hampshire Fish and Game Department)

weekly until the normal daylight period for that date is reached. Thereafter, all the panels on the brood house are closed and, by switching to the use of artificial lights, the "day" is shortened 1 hour weekly until there are 4 hours less of artificial light than there are hours in the normal daylight period for that date. The light-control switch remains fixed to maintain this condition until the fish ripen.

Diet

The diet consists of the following formula:

	Percent
Cod-liver oil	2
Brewers' yeast	2
Wheat flour middlings	11
Cotton seed meal	11
Distillers' corn grain solubles	11
Fish meal	11
Salt	2
Beef melts	35
Beef livers	15

1951-54 Summary

After a complete review of the history of the yearling brook trout being carried in our nine production units, the trout from the Warren Hatchery were selected as a source from which to pick those specimens that were best suited to the early-light project. The selection of stock was based on careful consideration of such characters as color pattern, size, resistance to disease, and general appearance.

One lot of 4,307 yearlings was sorted and sexed. Seventy-four percent of this lot were retained as excellent specimens, based on the afore-mentioned merits. The sex ratio was 47 percent females to 53 percent males.

On January 2, 1952, 1,615 females and 835 males from this lot at the Warren Hatchery were transported to the New Hampton Hatchery and placed in the brood house. This resulted in a carrying capacity of approximately 1.5 pounds per cubic foot of water. It should be noted that at this time the stock was only partially spawned out, and it was assumed that some time would be necessary to carry the fish over an ungovernable period in the sexual cycle. On January 15, 1952, controlled-light operations were started as already described.

Commencing on August 28, 1952, 2,655,000 eggs were collected from 1,300 trout of the 2.5-year-old class, averaging 2,000 eggs per female. The eggs were small (450 to the ounce); but although losses encountered during the period of incubation were higher than normal, those eggs that reached the eyed stage (some 1,500,000) developed into excellent fish. On May 5, 1953, these fingerlings ran 480 to the pound, whereas the regular stock averaged 2,000 per pound, though all growth factors such as diet, water temperature, and carrying capacities were equal.

During stripping operations we had opportunity to examine carefully our brood stock, and from those fish we selected 500 females and 200 males to be carried through the experiment a second time; the remaining fish were stocked. It was hoped that the eggs taken from the 3.5-year-old stock would be larger than and superior to the eggs collected from the 2.5-year-old class.

Thus the following year, commencing on January 15, 1953, when we repeated the procedures, the development of the reproductive organs of these trout was conditioned to the light experiment and the problem of late spawners was eliminated.

On the basis of the average egg yield per female fish of the 2.5-year-old stock, we estimated that 500 females would produce approximately 1,000,000 eggs, or 2,000 eggs per female. This was not the case. Commencing on August 13, 1953, from 135 females we collected 410,000 eggs, an average yield of approximately 3,037 eggs per fish. It should be stated, however, that these eggs were small (531 per ounce) and exhibited much buoyancy prior to reaching the eyed stage; therefore, egg collections were curtailed at that point. The egg losses were heavy, and many of the fish from this stock were deformed. After the removal of these culls, the remainder of the fish developed normally and in development were very similar to the previous lot.

The use of 3.5-year-old stock for the second series of experiments clearly demonstrated that, when carrying 3.5-year-old stock, there were many problems that were not evident when carrying 2-year-olds. Therefore, it was decided to use 2-year-old stock hereafter.

For the third year of the experimentation in light modification, 800 females and 400 jack yearlings were transferred to New Hampton from the Summer Brook Rearing Station of the New Hampshire Fish and Game Department. These fish were carefully selected in the same manner as the original stock from Warren. The experiment started on January 15, 1954; and as these were yearlings which had only partly thrown their eggs, it again became necessary to carry the fish through a refractory period in the sexual cycle.

Egg-collecting operations were started on August 9, 1954, and 697,734 eggs (with an average count of 420 per ounce) were collected from 268 females. The average yield (approximately 2,600 per fish) was higher than previous results. It has been noted that although the eggs are small, this lot has suffered only normal losses and the resulting fingerlings are excellent. It should be noted that only a part of the total number of available females was stripped, for the egg yield per female was high and we have calculated our annual needs at 500,000 eggs from this project.

Conclusions

Although there are many problems related to maintaining and collecting eggs from early-spawning brook trout stimulated by artificial light, the results have been favorable and the Fisheries Division considers the work a successful phase of its over-all production program.

Immediately after the collection of eggs from our brood fish, they are released into open waters for the purpose of angling.

As a result of our findings, we are firmly convinced that the use of 2.5-year-old brook trout for brood stock is more satisfactory than maintaining fish of the 3.5-year-old class for the same purpose.

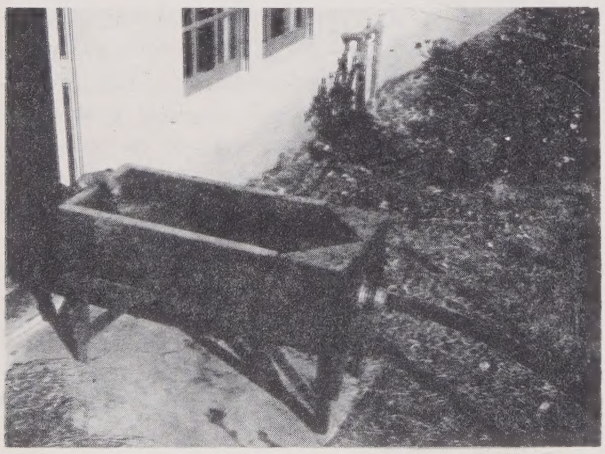
TRANSFER OF FISH FROM TROUGHS TO PONDS

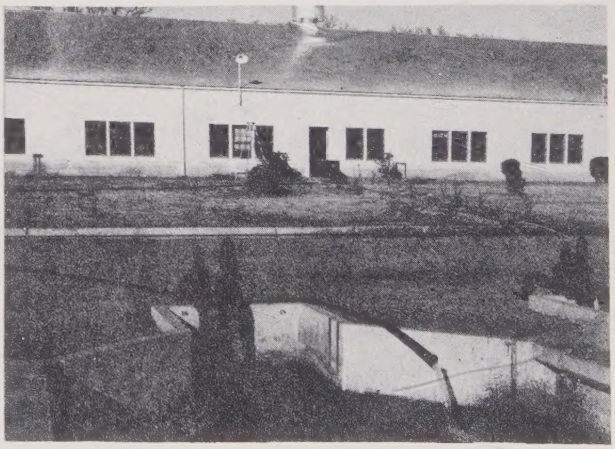
Fish are piped from trough to pond, with a considerable saving of handling and labor costs, at the Coleman (California) Fish-Cultural Station of the U. S. Fish and Wildlife Service. Using the equipment assembled for the purpose by John Pelnar, district supervisor, station personnel will be able to move 23 million advanced fry from troughs to ponds in little more than a fourth of the time required when using the truck-tank method of transfer.

Set between two hoses is a collecting box (about 16 inches wide, 16 inches deep, and 48 inches long). At one end of the box, a hose that is 1.5 inches in diameter introduces water in sufficient volume to form and maintain about a 4-inch head on the outlet of the second hose. The second hose--plastic, noncollapsible, and 2 inches in diameter--is attached at the opposite end of the box. This plastic hose is laid from the collecting box to the ponds at a slight down grade to prevent formation of any air locks or retardation of the flow. Fish that have been removed from the troughs--or fish merely lifted in their trays--are poured into the box, and the water carries them through the plastic hose to the pond.

The collecting box and both hoses can easily be moved by one man to and from desired locations. Thus it is possible to place the box on a trough and then lay the hose across the tops of a number of intervening troughs in order to transfer fish to a distant trough, or the same procedure may be applied to shift fish from one pond to another if a water supply is available either by pumping or gravity flow.

Arrangements similar to this are in use at a number of Service hatcheries on the west coast.





A NEW TWO-WAY FISH TRAP FOR STREAMS

Marvin J. Whalls, Karl E. Proshek, and David S. Shetter
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Lewiston, Michigan

ANY STREAM TRAP THAT SUCCESSFULLY CAPTURES AND HOLDS THE MIGRANT FISH is a useful tool in fishery research and management. Shetter (1938), Carbine and Shetter (1945), Wolf (1951), and Reid (1953) have enumerated the value of fish traps in studying diverse fishery problems. A new type of two-way fish trap has been developed at the Hunt Creek Fisheries Experiment Station. Its primary function is to confine migrating brook trout temporarily in order to enable the staff to follow accurately the annual movements of these fish in the stream.

Terminal concrete weirs are located on Hunt Creek (figure 1) at the lower ends of sections Z and D, approximately 1.99 miles apart. The lower bulkhead, at section Z (figure 2), is the one we are concerned with in this paper. At the section Z bulkhead, Hunt Creek is 37.5 feet wide and has an average depth of 1.2 feet. The bulkhead retains a normal head of 2.5 feet of water. The bottom type below the bulkhead is gravel and sand; that above is mostly sand, which, for the most part, has been carried in and deposited by the deceleration of the water as it nears the bulkhead. According to measurements made by the U. S. Geological Survey (data for the period from April 1949 to April 1950), annual average discharge through the Z bulkhead is about 23.2 cubic feet per second, with a range from 15 cubic feet per second to 55 cubic feet per second. A flow in excess of 80 cubic feet per second through the Z bulkhead will cause the traps to overflow and allow fish to escape, even though all screens are kept clean.

The present operation setup at the Z bulkhead (figure 2) consists of a self-cleaning rotary screen at either side, four Wolf traps to capture fish moving downstream, and, directly in the center, the newly devised trap for taking fish moving either upstream or downstream. Further information and construction plans for any of these devices may be obtained by writing to the Michigan Department of Conservation, Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan.

The self-cleaning rotary screen is expensive to maintain. The Wolf trap has the important limitation of handling only a small water flow, so that flood water overtops the trap and causes a loss of fish. Also, both the rotary screen (when not operating) and the Wolf trap retard the current sufficiently to allow an undesirable deposition of sand, silt, vegetation, and detritus just above the bulkhead. Prior to the development of the new two-way trap, upstream-migrating fish were caught in a V-shaped up-trap, a type of trap that is still used at the section D bulkhead (figures 3 and 4) but that is believed to retard the free migration of fish. The new two-way trap was devised to overcome the limitation of the rotary screen, the Wolf trap, and the V-shaped up-trap, i.e., to pass more water downstream without overtopping, to retain all migrating fish, to allow less restricted migration of fish, and to avoid deposition of sand, detritus, and so forth.

The evolution of the two-way trap began with attempts to improve the V-shaped

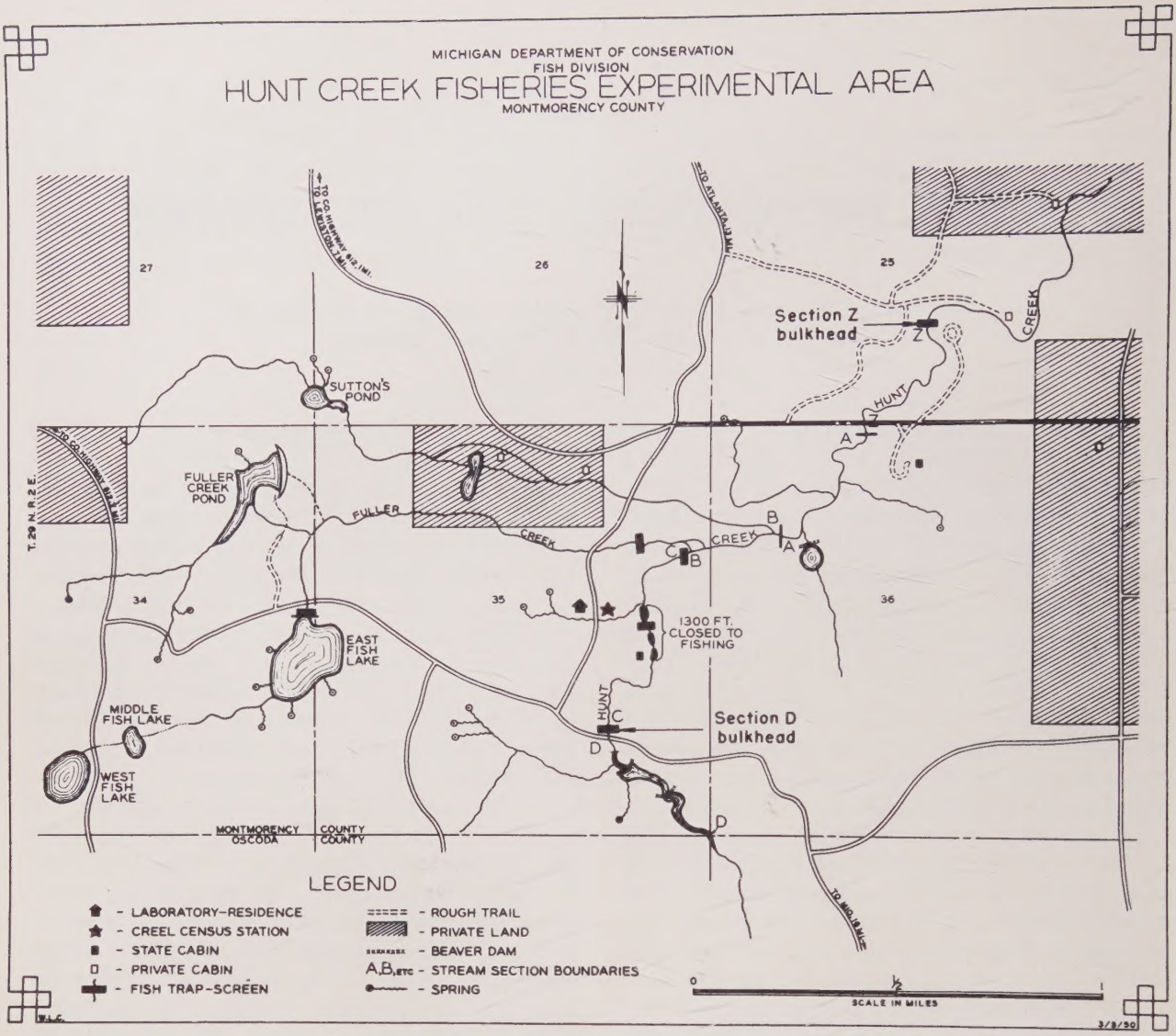
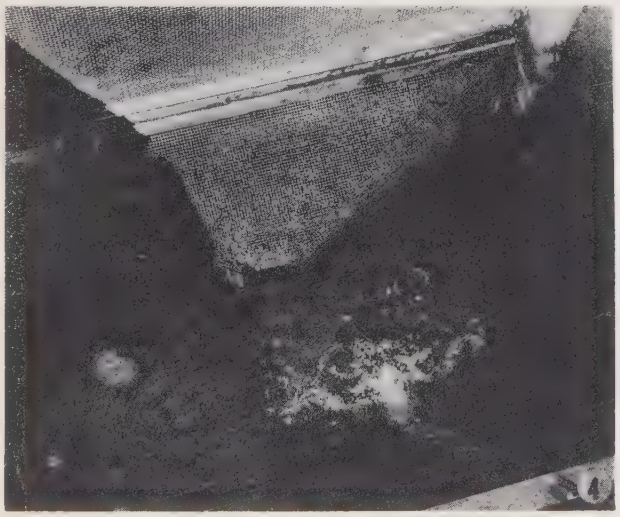


FIGURE 1.--Hunt Creek experimental area.
(Illustrations courtesy of the authors)

up-trap. Mr. Proshek reasoned that a screen laid horizontally in the bulkhead would handle much more water than would a vertical screen, because the horizontal screen would present a larger surface area for water passage. In August 1950, he built into the bulkhead a horizontal screen, as in figure 5 (B). At that time neither an upstream stop-screen nor a holding box for migrant fish was included. This setup was a big improvement over a vertical screen and did pass much more water. It had one serious fault: the horizontal screen became plugged with dirt and debris too much to be dependable. One day, when Mr. Proshek closed the structure for cleaning, he observed the effect when the inlet flow was restricted: the water rushed rapidly over the screen, picked up the dirt and debris, and carried it away. With that, the basic design for the new trap was established. This horizontal screen with its rushing, turbulent water had one serious fault: it killed fish.

To overcome the fish-killing character of the trap, a "calm" box was installed in the horizontal screen. This rectangular



box, about 12 inches deep and 14 inches on the sides, was built directly into the horizontal screen to provide a resting place for fish that entered the trap and to provide a place for dirt and debris to settle. With this improvement, the trap functioned well, but still a few fish were being killed because the debris filled the calm box and prevented the fish from entering the protected water. A larger calm box was needed. This fault was remedied by constructing a chute at the downstream end of the horizontal screen to direct the water, fish, and debris into a large holding box on the downstream side of the bulkhead. In figure 2, this is the box to the left, occupying the center slot of the bulkhead; in figure 5, this box is in the right foreground. This holding box is essentially two boxes, a wire screen box contained within a wooden box, being held apart by wooden braces.

Although no detailed study has been made of the physical principles which contribute to the success of the new two-way trap, casual observations have led us to believe that the down-trap functions in the following manner: Water enters the trap inlet (figure 5, A) with considerable velocity because of the weight and velocity of the water above the inlet. This produces a horizontal force across the screen, a force which tumbles debris and fish to the rear of the trap. Although the bulk of the water passing through the inlet drops through the horizontal screen and passes through the outlet (figure 5, C) and into the up-trap, a small volume of water carries the fish and debris across the

FIGURE 2.--Section Z bulkhead. The concrete weir contains the rotary screens, Wolf traps, and new two-way fish trap. Each bulkhead slot measures 48 inches, wall to wall.

FIGURE 3.--Section D bulkhead, looking upstream. The V-shaped up-trap (center slot) is operating.

FIGURE 4.--Section D bulkhead, looking downstream. V-shaped funnel leads into the V-shaped up-trap. The water has been shut off.

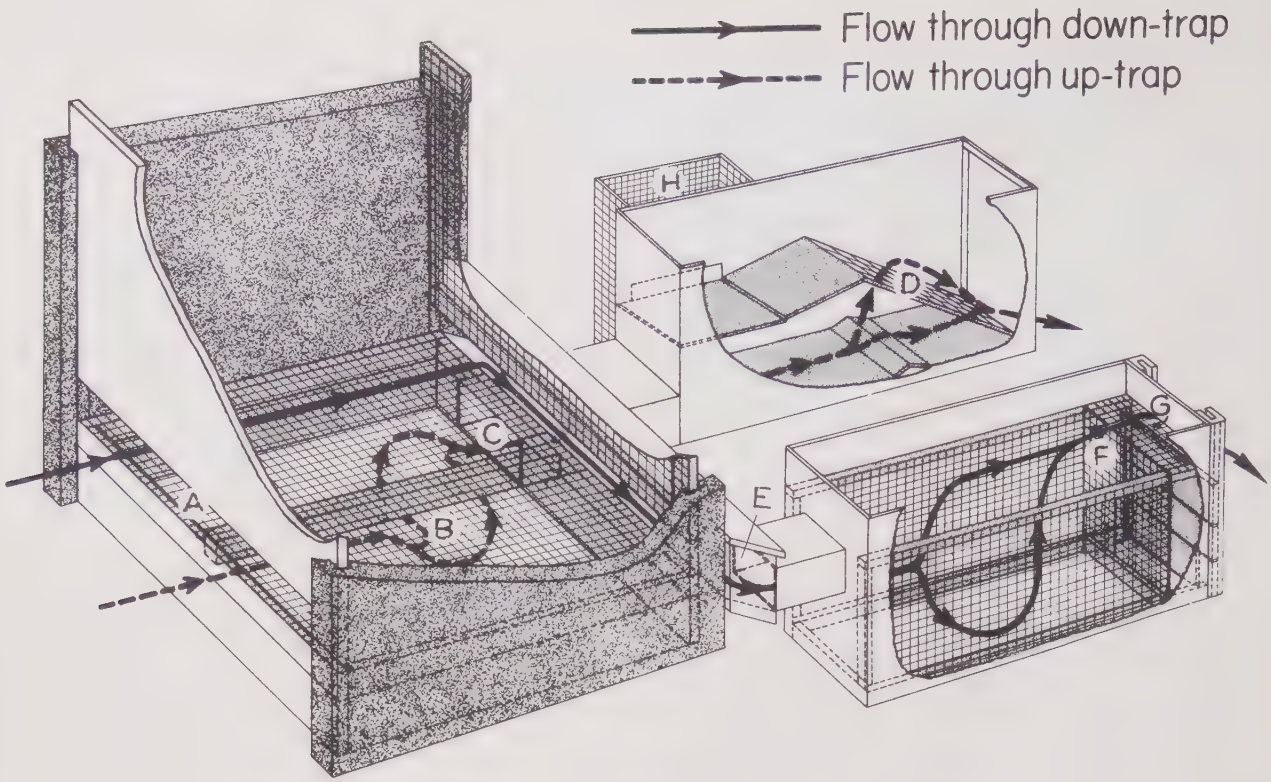


FIGURE 5.--The new two-way fish trap.

horizontal screen, into the chute (figure 5, E), and into the down-trap holding box, where the water passes through the screen (figure 5, F) and out of the wooden box over the spillway (figure 5, G). The fish and debris are retained in the box.

Once the fish have entered the down-trap, they cannot leave, as they are unable to swim through the rushing water passing over the horizontal screen. This trap, when set up correctly, does not kill fish. Our observations lead us to believe that the fish enter this trap voluntarily and are not "sucked in."

A slight vertical oscillation of the horizontal screen is produced by a constant fluctuation in the outlet flow. When the space under the horizontal screen (figure 6) completely fills with water, the shearing force of the horizontal movement of water over the face of the screen produces a slight vertical lift on the water under the screen (Bernoulli's effect). This vertical lift quickly ceases when a slight

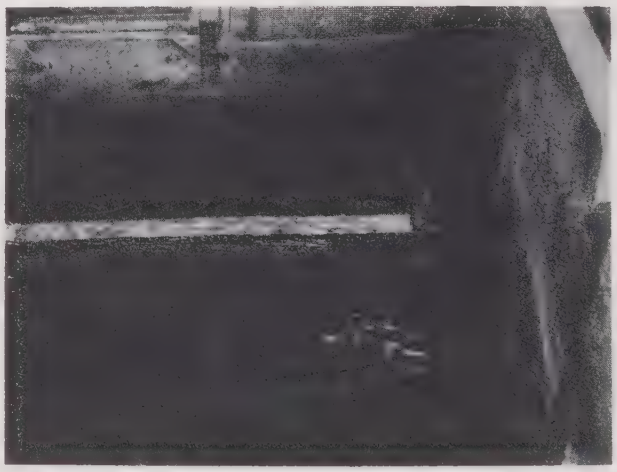


FIGURE 6.--Section Z bulkhead. Horizontal screen usually on 2x4 legs at right has been removed to show outlet chute (lower left) to up-trap and outlet chute (center, reaching almost across distant wall) to down-trap holding box. White area (right) in upper chute marks entrance to holding box.

drop occurs in the water level below the screen, and water again drops through the screen to fill the void. The cycle of up-and-down movements of the screen and the water and the horizontal movement of the water over the screen combine to keep the screen free of debris. To maintain this condition, the volume of water entering the trap must equal the volume of water leaving the trap. The flow is regulated by adjusting the stop-screen.

The new down-trap has had little effect on the number of fish moving downstream (figure 7). Nor has there been any detectable change in the size composition of the fish moving downstream. The fluctuation in the number of fish moving downstream is believed to be caused by factors other than the down-trap, such as success of spawning and climatic variations. The new down-trap did help to stabilize the volume of water passing through the Z bulkhead and did help to keep the stream area above the trap from becoming filled with sand and debris. Once installed, this trap has required little maintenance. After the down-trap was made to function satisfactorily, our attention was focused on devising an upstream trap to work in conjunction with the down-trap.

One of the reasons the V-shaped up-trap failed to function at the Z bulkhead was the lack of a concentrated volume of water flowing through the trap. Most of the water was passing through the Wolf traps and not through the up-trap; thus the fish moving upstream were attracted to the impassable Wolf traps. When the new down-trap was constructed, the outlet (figure 5, C) for the water passing through the horizontal screen was restricted to a 25- by 16-inch opening. The water that passed through this opening was seen to attract fish. Fish were seen swimming up the outlet. They did not swim through the water but on the surface with the lower part of their bodies submerged, or they simply leaped. This observation gave rise to the possibility of devising a trap which would hold these fish.

Consequently, in August 1952, a shallow U-shaped trough (not shown) of 0.5-inch mesh galvanized metal screen was partly

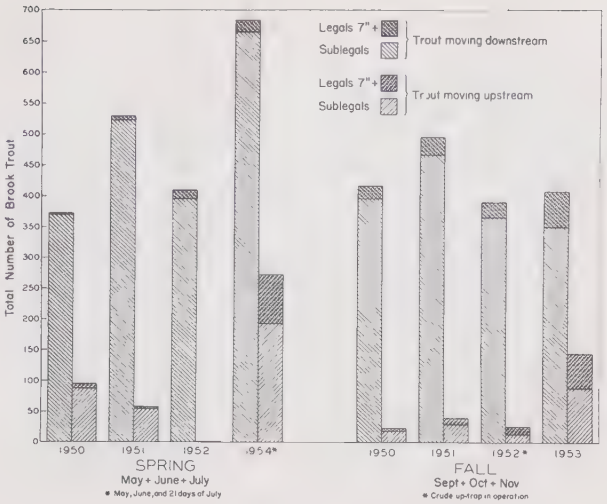


FIGURE 7.--The spring and fall movement of brook trout through the section Z bulkhead.

submerged at the upper part of the down-trap outlet, and the trough was inclined at such an angle that any fish swimming or jumping the outlet would fall into the inclined trough and slide down into a wooden holding box. The trap did capture fish but not much better than the V-shaped trap. It was recorded, however, that the jump trap took a larger percentage of legal fish (larger than 7 inches) than did the V-shaped trap (figure 7, 1952, up).

In an attempt to improve the crude jump trap, the present jump trap (figure 5 and figure 2, the box to the right in the center slot) was built and installed during August 1953. The new up-trap is basically a low falls (figures 5, 8, and 9). The only difference is that the fish, after swimming or jumping up the falls, land on a series of inclined wooden boards that direct the fish into an escape-proof holding box (figure 5, H). The water that passes through the up-trap is supplied from that which passes down through the horizontal screen in the bulkhead.

The new up-trap has been significantly more efficient than previous traps in allowing the upstream movement of fish. Figure 7 shows the increased upstream movement that occurred in the autumn of

FIGURE 8.--Section Z bulkhead. A closeup showing the downstream side of the down-trap holding box (left center) and the falls created by the new up-trap (right center).

FIGURE 9.--Section Z bulkhead. A view of the new up-trap, showing the inclined boards which direct the fish into the small holding box (lower center). The down-trap holding box is at upper right, and a part of a Wolf trap is at lower left.

1953, when this trap was first installed, and a repetition of the increase again in the spring of 1954. The new up-trap has taken brook and rainbow trout that ranged in size from 3.4 to 12.6 inches, white suckers from 3.1 to 14.1 inches, and common shiners, creek chubs, and blacknose dace from 3.5 to 4.8 inches--the normal size range of the fish in the experimental area. No rough fish or forage fish were ever taken in the V-shaped up-trap.

There are several refinements that could be made on the new two-way trap. For one, the up-trap and the down-trap holding boxes could be combined into one box to save lumber and labor. Another, the outflow from the downstream holding box could be made to pass through the up-trap to increase further the volume of fish-attracting water passing through the trap. Also, the level of the horizontal screen above the base of the bulkhead could be varied so as to determine the level at which the most water would be passed without deterring the movement of fish. Also, there could be a better horizontal screen-to-bulkhead sealing device that would eliminate the necessity for cleaning the inclined screen (figure 5, D) on the up-trap.

The dimensions that are given here for the new two-way trap are those that were used at the section Z bulkhead. The dimensions will necessarily have to be altered if the trap is installed in a weir that differs in construction or water discharge. The slot between the concrete piers at the bulkhead (figure 5) is 4 feet wide, 8 feet long, and 4 feet deep. The horizontal screen is 6 feet 10 inches long and 4 feet wide; this screen is supported 14 inches from the bottom by a frame made of 2 x 4 boards. The downstream holding box is 4 feet long, 3 feet deep, and 2 feet wide. The upstream trap is 5 feet long, 3 feet deep, and 2 feet wide. The top of the upstream trap and the top of the downstream holding box are on the same level: they are 1 foot above the level of the horizontal screen. The lumber that was used in building the trap consisted of 2 x 4 and 1 x 6 fir. The screens were constructed of galvanized hardware cloth that had 6 openings to the inch.

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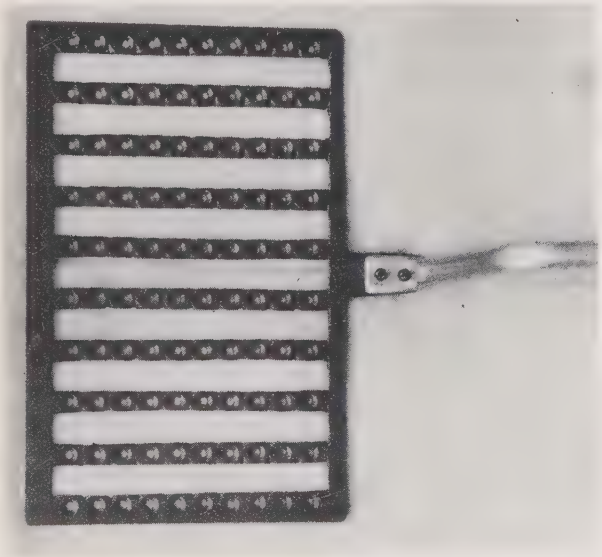
AN EASILY MADE EGG COUNTER

An egg counter formed from plexiglass and fashioned after counters in use at the Coleman (California) Fish-Cultural Station is giving satisfaction in the Pacific Salmon Investigations of the U. S. Fish and Wildlife Service. Robert D. Broad, fishery biologist at Seattle, Washington, has reported that plexiglass is easily worked, very strong, flexible, nontoxic to fish eggs, and has a slick finish to which excess eggs do not adhere.

This egg counter was made from a sheet of plastic, 7- by 9-1/2- by 1/8-inch. Ten rows containing 10 holes each were drilled in the sheet. These rows were spaced 1 inch apart on center. In each row the holes, 3/16-inch in diameter, were bored at 1/2-inch intervals and were countersunk at 100° pitch in order to form pockets into which eggs would fit. Notches were scribed in the countersunk portion of each hole to decrease the surface tension between the counter and the eggs. The surface of the counter was reduced by cutting out as much material as possible between the rows of holes. The strip left as a frame, 1/4-inch in width, was too narrow for excess eggs to stay on but was wide enough to give the counter ample strength. A handle was made from a piece of aluminum tubing, 1/2-inch in diameter, and riveted to the counter.



While in use, the counter is dipped into a basket of eggs and lifted vertically so that a single egg will come to rest in each pocket of the counter. Eggs can be tallied quickly and easily, 100 at a time. Although the counter is not subjected to any strain during use, the ruggedness of the plastic insures against accidental bending or breakage.

Egg-counting devices fashioned of other materials have been described in earlier issues of THE PROGRESSIVE FISH-CULTURIST, as: counter described by Stack and used in bakelite by Haskell (Haskell 1952: 81-82), Canady's iron sampler (Burrows 1951: 81-82).

THE EFFECT OF STARVATION UPON BROOK TROUT OF THREE SIZES

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THE EFFECT OF PROLONGED FOOD DEPRIVATION UPON SURVIVAL OF FISH has been a major concern of fish culturists and aquatic biologists alike. Studies in the past have unequivocally demonstrated that reduction in weight is an increasing function of the length of the deprivation period (Lawrence 1941). However, no such uniformity is found in results concerning the effect of starvation on mortality. Lawrence (1941), for example, found a very great mortality after but 28 days' deprivation. Cortland studies (Phillips et al. 1953) revealed that the interaction of "high" water temperatures (51°) with starvation produced mortality after the first 10 weeks of the study. Lower water temperatures (47°), however, had little effect upon mortality over the same period.

The study of the effect of food deprivation upon mortality has important implications to the biologists who are interested in the problem of winter mortality. The inability of fish to survive the rigors of winter weather has been highly resistant to empirical explanation. However, as the arrival of cold weather renders most streams relatively sterile, it would follow that little food would be available to the fish population. Thus, an explanation of low winter survival might possibly be that fish die of starvation as a consequence of a dearth of aquatic food concomitant with the approach of cold weather.

The present study was designed to test the hypothesis that starvation is a significant determinant of the fishes' inability to sustain the winter months. In general, the procedure was to deprive three groups of brook trout (Salvelinus fontinalis)--3.5 inches, 5.5 inches, and 7.5 inches in length--of food for 7 months. The complete study was conducted at the Oden Hatchery, Emmet County, Michigan, during the period from September 15, 1953, through April 15, 1954.

Procedure

Hatchery-reared brook trout selected for lengths of 3.5, 5.5, and 7.5 inches were placed in sections of a standard hatchery fingerling trough. The sections were 13 inches long, 14.5 inches wide, and 10 inches deep. Water level was kept at 7 inches, and a constantly changing water supply flowed from a ground source at the rate of 6 gallons per minute. All water in the trough was filtered through gravel and fine netting (0.25 inch in thickness) at the head end. The water temperature was 45° F., plus or minus 0.5°.

Each of the aforenamed length groups was divided randomly into two groups of 20 fish each. Half of each length group was weighed and measured weekly for a 1-month period and biweekly thereafter,

Psychological Research Services, Inc., is under contract to the Michigan Department of Conservation.

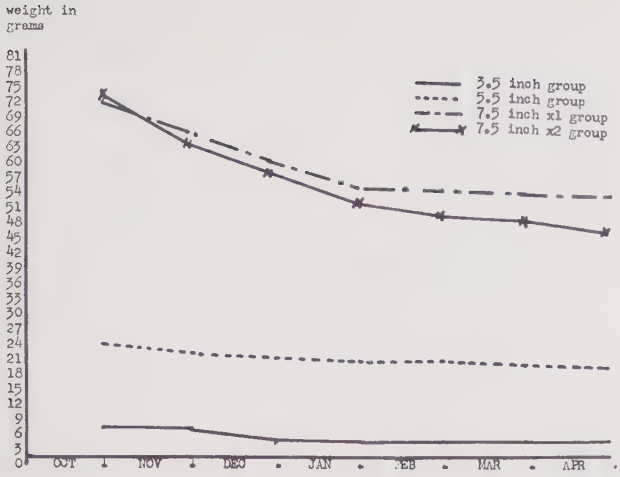

FIGURE 1.--Mean monthly weights for four groups.

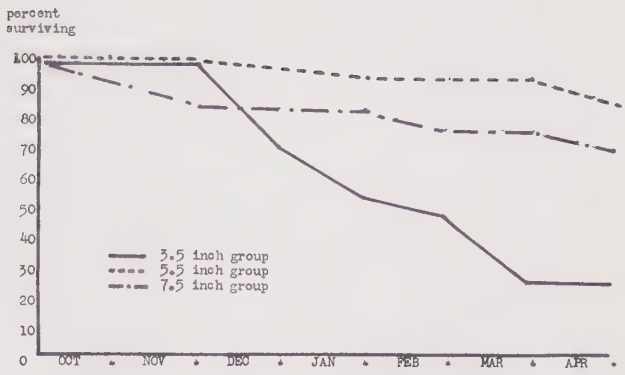

FIGURE 2.--Percentage survival as a function of continuous food deprivation.

(Drawings courtesy of the authors)

while the remaining half served as a control for the handling procedures. Thus, each experimental group was anesthetized with ether, weighed and measured, and treated for fungus and gill infection with pyridyl mercuric acetate. The control groups were not handled but were treated for fungus and gill infection. Treatment of these diseases was undertaken to offset damage to the fish through handling and confinement procedures.

In addition to the foregoing, the 7.5-inch group was divided into four randomly selected groups. Two groups of 20 (X1) fish each were confined in a space comparable to that of the 3.5- and 5.5-inch groups, and two groups (X2) of 20 fish each were confined in an area three times as large. This procedure resulted in a space-per-fish factor of 6 and offered a comparison with respect to the influence of confinement.

At the beginning of spring, all surviving fish were divided into two randomly selected groups. One group was put on a demand feeding schedule; i.e., these fish were fed as much as they could eat. The other group was fed small increasing increments until full daily rations could be offered. Thus, this procedure offered a method of determining the most effective method for restoring starved fish to normal weight.

Results

The results of weight determination throughout the course of this experiment are presented in figure 1. As can be seen, the weight of all four groups gradually declined in the initial phases of the study and remained relatively constant over the last 4 months of starvation. The magnitude of decrease from the initiation to the termination in all four groups was not statistically significant. Figure 1 reveals that the two groups of larger fish showed more loss of weight than did either of the groups of smaller fish. As the groups of larger fish showed fewer continuous mortalities, the relative weight constancy of the smaller fish may have been due in part to the death of the fish which would have reduced the mean weight of the groups. Therefore, this finding may be nothing more than an artifact of the methodology herein employed.

The results of the survival portion of this study are presented in figure 2. As handling and amount of confinement space had no systematic influence upon survival rate, the results portrayed are for the three major experimental groups. As is readily apparent, hunger produced the most detrimental effect on the 3.5-inch fish, which survived at the rate of 30 percent at the end of 7 months. The 5.5-inch

fish and the 7.5-inch fish survived at rates of 90 percent and 75 percent, respectively. The differences between the latter two groups and the 3.5-inch groups of fish were significant beyond the 1-percent level of confidence (X2), while the differences between the two groups of larger fish were not statistically reliable. Blood counts taken by Dr. L. N. Allison, fish pathologist of the Michigan Department of Conservation, in March revealed that even after 5 months of complete food deprivation, none of the fish had a pathologically low count and--although the smaller fish had lower counts--all were well within the normal range.

Upon termination of the study in May, the groups were divided at random into a demand-feed group and a slow-feed group. All the fish in the demand-feed group died, whereas none of the fish in the slow-feed group revealed these debilitating effects. Thus it would seem that after a prolonged period of starvation, fish, like human beings, must be fed slowly to insure recovery and rebuilding of former condition.

Discussion

From the results of the foregoing study it is evident that, for larger fish, at least, starvation per se could not be an important variable in low winter survival rates. As the water temperature that was utilized varied around 45°, the survival obtained probably represents an overestimate of mortality, inasmuch as past studies tend to indicate that fish can survive without food in an inverse ratio to water temperature (Lawrence 1941, Phillips et al. 1953). Therefore, the typical winter stream temperature of slightly above freezing would slow metabolism to the point where lack of food would make few inroads upon survival rates. Therefore, we must look to other variables for explanations of this phenomenon.

An alternate interpretation may be that winter loss is due to immobility concomitant with low metabolism. By remaining relatively immobile, the fish would be subject to various types of predation which could cause significant losses. However, whether or not depredation is the prime variable contributing to low winter survival rates for fish, remains an empirical question.

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A STABILIZER OF NET OR SEINE

To confine fish easily and speedily, J. G. Perry of the U. S. Fish-Cultural Station at Saratoga, Wyoming, recently devised a way to stabilize the net or seine.

Mr. Perry's stabilizer requires some suction cups (car-top-carrier type), two strips of rubber from an old inner-tube, and two blocks of wood. The suction cup has steel threads inside for the bolt to screw into--and wood-screw threads on top to screw into the bottom of a seine pole. The suction cups hold the seine on the bottom of the tank and in place next to the sides so that fish cannot get past the seine. The blocks of wood, cut in the form of 7's from 1-inch stock, are held against the top of the outer edge of the tank with the rubber bands stretched from the poles; the blocks keep the top of the seine in place.

TOXICITY OF MALATHION 500 TO FALL CHINOOK SALMON FINGERLINGS

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and
Harlan E. Johnson, U. S. Fish and Wildlife Service, Cook, Washington

STUDIES TO DETERMINE TOXICITY OF MALATHION 500 to fall chinook salmon fingerlings were made recently near Cook, Washington, at the Little White Salmon Fish-Cultural Station of the U. S. Fish and Wildlife Service. Personnel of the U. S. Public Health Service assisted in the planning and execution of the experiments.

Malathion 500 is an emulsifiable concentrate of the insecticidal thionophosphate known as malathion (o, o - dimethyl dithiophosphate of diethyl mercaptosuccinate) with aromatic petroleum derivative solvent (31 percent) and other inert ingredients (12.5 percent). Malathion is said to have insecticidal properties similar to those of parathion and tetraethyl pyrophosphate, being a cholinesterase inhibitor, but to be much less toxic than these to man and other mammals. The LD_{50} for rats has been reported to be 750 milligrams per kilogram when injected intraperitoneally and 1,500 milligrams per kilogram when administered orally, the absorption through the digestive tract being slow (DuBois et al. 1953).

The test animals were fall chinook salmon fingerlings about 1.5 inches in length. Nine slightly inclined wooden hatchery troughs, painted inside and outside with aluminum paint, were utilized as test aquaria. The troughs were about 648 centimeters long and 42 centimeters wide; they were filled with spring water to a depth averaging 30 centimeters (this being the depth of the water at the middle of each trough) after the outlets had been plugged.

The volume of water in each trough was approximately 590 liters. Malathion 500 is said to contain 5 pounds of malathion (active ingredient) per gallon, which is equivalent to 1 gram of the active ingredient in 1.67 milliliters of the commercial product, or 1 milligram in 0.00167 milliliter. Accordingly, 0.985 milliliter of Malathion 500 (0.00167 milliliter x 590) added to the water in the trough should give a concentration equivalent to 1 part per million of the active ingredient. All concentrations reported herein were computed on this basis.

Different amounts of Malathion 500 (emulsified by being mixed in a flask with 99 times its volume of water and then shaken vigorously) were added to the water in 7 of the troughs; the remaining 2 troughs served as controls. In the first experiment, begun on March 30, 1954, the measured quantities of concentrated emulsion were added directly to the water in the troughs; whereas in the second experiment, started on April 12, 1954, these quantities were made up to 1 liter with water--so as to promote uniform dispersion of the toxicant--before being poured into the troughs. After the experimental dilutions of the toxicant in the troughs had been thoroughly stirred, 20 salmon fingerlings were introduced into each trough. Periodic observations and records of the mortality were made for 6 days thereafter.

The results of the first bioassay are presented in table 1. It will be noted that 0.1 part per million of malathion (active ingredient) killed some fish within 24

hours, and nearly all the fish in 6 days, at temperatures between 44° and 48° F. The critical concentration range is shown to be between 0.032 and 0.32 part per million of malathion; but because of the wide intervals between the different concentrations tested, median tolerance limits could not be accurately estimated by interpolation (Surber and Bartsch 1952).

The results of the second bioassay are reported in table 2. They indicate somewhat greater resistance of the fish to the toxicant than was indicated by the first series of tests. No explanation for this apparent increase of resistance can be given. The intervals between the concentrations tested were small; and the somewhat greater mortality that was observed in the trough with 0.087 part per million of the malathion, as compared with the next higher concentration (0.1 part per million), evidently is fortuitous, or ascribable to experimental error. At the test temperature of 47° to 49° F., most of the test fish tolerated 0.087 part per million and 0.1 part per million of malathion for 6 days, but only slightly higher concentrations proved fatal to most of the fish, and the highest concentrations tested (0.24 part per million and 0.32 part per million) killed nearly all the fish within 24 hours. Therefore, it was possible to estimate median tolerance limits for exposure periods of 24, 48, and 96 hours by straight-line interpolation, in accordance with the recommendations made by Doudoroff et al. (1951). These values have been shown in table 2. The median tolerance limit (TL_m) is defined as that concentration of a toxicant at which just 50 percent of the test animals are able to survive for the specified period of exposure.

TABLE 1.--Results of first experiment on toxicity of Malathion 500 to chinook salmon fingerlings
(March 30 to April 5, 1954)

Concentration as p.p.m. malathion[1]	Trough No.	Percent survival after-- 6 hrs.	24 hrs.	48 hrs.	96 hrs.	144 hrs.
10	66	0	0	0	0	0
3.2	65	0	0	0	0	0
1.0	64	0	0	0	0	0
0.32	63	0	0	0	0	0
0.1	62	100	90	65	25	5
0.032	61	100	100	100	100	100
0.01	59	100	100	100	100	100
Control	60	100	100	100	100	100
Control	58	100	100	100	100	100
Temperature (°F.)		44	45	46	48	48

[1] Active ingredient.

TABLE 2.--Results of second experiment on toxicity of Malathion 500 to chinook salmon fingerlings
(April 12 to April 18, 1954)

Concentration as p.p.m. malathion[1]	Trough No.	Percent survival after-- 6 hrs.	24 hrs.	48 hrs.	96 hrs.	144 hrs.
0.32	66	55	5	0	0	0
0.24	65	85	5	0	9	9
0.18	64	95	40	10	0	0
0.135	63	100	95	80	15	5
0.115	62	100	100	90	55	15
0.1	61	100	100	100	90	80
0.087	59	100	100	100	75	75
Control	60	100	100	100	100	100
Control	58	100	100	100	100	100
Median Tolerance Limits (TL_m as p.p.m. malathion		--	0.17	0.15	0.12	
Temperature (°F.)		47	48	49	49	49

[1] Active ingredient.

Subsequent bioassays were performed by Johnson, from June 1 to June 13, in order that he might determine the toxicity of Malathion 500 after the insecticide had been held in the water of the experimental troughs for periods of as much as 144 hours before the introduction of the salmon fingerlings. The results are presented in tables 3-5 for holding periods

TABLE 3.--Toxicity of Malathion 500 to chinook salmon fingerlings introduced 48 hours after addition of insecticide

(June 3, 1954)

Concentration as p.p.m. malathion[1]	Percent survival after-- 6 hrs.	24 hrs.	48 hrs.	96 hrs.	144 hrs.
1.0 --------	0	0	0	0	0
0.32 -------	55	0	0	0	0
0.1 --------	100	100	100	100	100
Control ----	100	100	100	100	100
Temperature (°F.) ----	51.5	52.0	52.0	52.0	54.0

[1] Active ingredient.

TABLE 4.--Toxicity of Malathion 500 to chinook salmon fingerlings introduced 96 hours after addition of insecticide

(June 5, 1954)

Concentration as p.p.m. malathion[1]	Percent survival after-- 24 hrs.	48 hrs.	96 hrs.	144 hrs.
1.0 --------	0	0	0	0
0.32 -------	0	0	0	0
0.1 --------	95	95	95	95
Control ----	100	100	100	100
Temperature (°F.) ----	51.5	52.0	54.0	54.0

[1] Active ingredient.

of 48 hours, 96 hours, and 144 hours, respectively. These results agree fairly well with the earlier results shown in table 2. Because of higher experimental temperatures, the data obtained in the later tests are not strictly comparable with data that were obtained earlier. It is apparent, however, that aging for periods of as much as 144 hours did not have any very important effect upon the toxicity of dilute emulsions of Malathion 500.

Summary and Conclusions

The bioassay results that are reported herein show that a concentration of emulsified Malathion 500 equivalent to 0.1 part per million of malathion (active ingredient) can be decidedly harmful to chinook salmon fingerlings. One toxicity evaluation showed the 24-hour, 48-hour, and 96-hour median tolerance limits to be about 0.17, 0.15, and 0.12 part per million of malathion, respectively, at temperatures of 47° to 49° F. The results of an earlier, preliminary series of tests indicated somewhat greater toxicity and a 96-hour TL_m a little below 0.1 part per million of malathion (at 44° to 48° F.); but 0.032 part per million, the next lower concentration tested, killed no fish in 6 days. Results of some later tests, wherein the insecticide was added to the water 48, 96, and 144 hours before the introduction of the test fish, agreed with the results of the first-mentioned toxicity evaluation (second experiment) and revealed no important change in the toxicity of the emulsions with aging.

It may not be assumed that all malathion preparations with equivalent content of the active ingredient would be as toxic to fish as is Malathion 500. However, the evident hazard to fish involved in the contamination of water with the insecticide in any form should not be overlooked.

TABLE 5.--Toxicity of Malathion 500 to chinook salmon fingerlings introduced 144 hours after addition of insecticide

(June 7, 1954)

Concentration as p.p.m. malathion[1]	Percent survival after-- 24 hrs.	48 hrs.	96 hrs.	144 hrs.
1.0 --------	0	0	0	0
0.32 -------	0	0	0	0
0.1 --------	100	100	100	100
Control ----	100	100	100	95
Temperature (°F.) ----	53.5	54.0	54.0	55.0

[1] Active ingredient.

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STUDY OF 2,3-DICHLORONAPHTHOQUINONE AS AN ALGAECIDE

Any fish culturist who may be confronted with the problem of controlling the growth of bloom-producing blue-green algae in his ponds will be interested in the experiments that are described by Fitzgerald and Skoog in the paper entitled "Control of Blue-Green Algae Blooms With 2,3-Dichloronaphthoquinone," which appeared in the September 1954 issue of Sewage and Industrial Wastes.

The paper summarizes the results of large-scale applications of 2,3-dichloronaphthoquinone, or 2,3-CNQ (which is now standardized as "dichlone"), to eliminate and prevent recurrence of heavy growths of the bloom-producing blue-green algae. The 2,3-CNQ was applied--in the form of a paste containing 50 percent active ingredient with wetting agent and 50 percent water--to a 27-acre, highly fertile Wisconsin lake that normally supported a continuous and heavy bloom of blue-green algae during the summer. Being miscible with water, the chemical was applied as a water spray pumped from a motor boat. Speed of the boat was varied in accordance with depth of water in an attempt to get uniform distribution of the spray, although the amount applied was increased in local areas that had exceptionally large masses of algae. The rates of application ranged from 18 to 50 pounds per treatment of the lake, corresponding to concentrations of 20 to 55 parts per billion. The growth density of the blue-green algae--and thus the effectiveness of the treatments with this algaecide--was estimated on the basis of analyses made on 20-quart samples of water taken from each of two or more fixed stations on the principal lake under study and from a nearby smaller lake.

Stating briefly the conditions observed during this study of the effectiveness of the chemical as an algaecide, Fitzgerald and Skoog concluded:

> Spray applications of 2,3-CNQ suspensions to give over-all concentrations from 30 to 55 p.p.b. in the lake clumped and effectively killed even heavy growths of the blue-green species. The chemical treatment had no observable harmful effects on green algae, higher aquatic plants, fish, or zooplankton. In cases of rapid recurrence of growth of the blue-green algae, repeated applications are necessary. The lasting effect of treatments, however, may be indirectly increased by vigorous growth of green algae and higher aquatics following the suppression of the blue-greens.

WEIGHT OF FISH PER CUBIC FOOT OF WATER IN HATCHERY TROUGHS AND PONDS

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AMONG HATCHERY PERSONNEL there exists little agreement on the safe carrying capacity of troughs or ponds. The method to be described here has been used at Rome for several years and, although admittedly not based on scientific data, is nonetheless considered valuable in the management of this hatchery.

The number of factors affecting carrying capacity makes preparation of general rules very difficult. These factors probably include species; fish size; water flow; water quality, i.e., dissolved oxygen, carbon dioxide, hardness; sanitation practices; type of food; and method and timing of feeding. If, however, two assumptions may be made, a rather simple rule may be derived for estimating the carrying capacity. These assumptions are--

1. Carrying capacity is limited by (a) oxygen consumption and (b) accumulation of metabolic products.

2. Amount of oxygen consumed and the quantity of metabolic products are proportional to the amount of food fed.

If the two assumptions are granted, and if the carrying capacity of a trough or pond is known for any particular size of fish, at a particular temperature, then the safe carrying capacity for other sizes and temperatures is that quantity of fish which will require the same weight of feed daily.

For example, the writer believes that brown trout fingerlings that have reached 1 inch in length may safely be held in troughs at a density of 1.75 pounds per cubic foot of water at 53° F.[1/] The recommended amount of feed for brown trout of this size is 7.6 percent of body weight daily (Deuel et al. 1952).

When the assumptions just made are applied, the maximum safe density of brown trout in a trough will be that weight of fish which requires 0.13 pound of feed per day per cubic foot of water. As for each temperature and size there is a recommended feeding level, one may use the following equation (wherein W is weight and BW is body weight):

$$\text{W of feed} = \frac{\% \text{ BW} \times \text{W of fish}}{100}$$

or

$$\text{W of fish} = \frac{\text{W of feed} \times 100}{\% \text{ BW}}.$$

Since a maximum feeding level of 0.13 pound per day per cubic foot has been defined,

$$\text{Permissible W of fish} = \frac{0.13 \times 100}{\% \text{ BW}} = \frac{13}{\% \text{ BW}}.$$

Using the last equation, one may look up the recommended feeding level for any size and temperature and easily calculate the permissible weight of fish. The results of these calculations for brown trout are shown in the accompanying table.

1/Rearing troughs: 13 feet 6 inches long, 1 foot 9 inches wide; water depth, 6-1/4 inches; 3 in a series; water flow, 15 gallons per minute.

For use with other sizes of troughs, species, or water flows, this table may not apply; but if the carrying capacity is known for any temperature or fish size, it is possible to compute a similar table.

On a similar basis, at Rome we use the following equation for the rearing ponds:

Maximum permissible density of brown trout in rearing troughs

Water temperature °F.	Pounds per cubic foot in rearing troughs containing-- Number of fish per pound:	-2542	2542-304	304-88.3	88.3-37.8	37.8-19.7	19.7-11.6
	Size (inches):	-1	1-2	2-3	3-4	4-5	5-6
38		2.4	3.0	3.7	5.0	6.5	8.1
40		2.3	2.8	3.4	4.6	6.2	7.7
42		2.2	2.5	3.2	4.3	5.7	7.2
44		2.0	2.4	3.0	3.9	5.2	6.5
46		1.9	2.2	2.8	3.7	4.8	6.2
48		1.7	2.1	2.5	3.4	4.5	5.6
50		1.6	1.9	2.4	3.2	4.2	5.2
52		1.5	1.8	2.2	3.0	3.9	4.8
54		1.4	1.6	2.0	2.7	3.6	4.5
56		1.3	1.5	1.9	2.5	3.3	4.2

$$\text{Permissible W of fish} = \frac{0.02 \times 100}{\% \text{ BW}} = \frac{2}{\% \text{ BW}}.$$

Thus, ponds are considered to have a carrying capacity of about one-sixth that of troughs on a cubic-foot basis.

If one concedes the above principles, interesting implications regarding production may follow. Heavier densities are possible at low temperatures than at high temperatures and are desirable for maximum production. Heavier densities are possible as fish size increases.

If the weight of feed per cubic foot is constant and one assumes a uniform conversion, then--for a trough or pond held at the maximum density--the production per cubic foot will be constant for all sizes and temperatures. Assuming a conversion of 3.0, production per cubic foot in troughs may be derived from the equation--

$$\text{Gain} = \frac{\text{W of feed}}{\text{Conversion}} = \frac{0.13}{3.0} = \begin{array}{r} 0.043 \text{ lb./day,} \\ 1.29 \text{ lbs./30-day month,} \\ 15.7 \text{ lbs./year.} \end{array}$$

For ponds, an equivalent production per cubic foot would be--

0.0067 lb./day,
.20 lb./30-day month,
2.44 lbs./year.

Under the limits imposed and the assumed conversion, this production cannot be attained unless the pond or trough is kept constantly at the maximum permissible poundage--which is practically impossible. The figures given constitute an upper limit or production under these circumstances.

In conclusion, the methods which have been given for computing the carrying capacity should be considered a temporary approach until further knowledge of water quality and trout metabolism provide the fundamental knowledge for a more realistic solution. It should also be pointed out that the "maximum" permissible densities suggested here have been exceeded many times in practice. Perhaps the table should have been titled "Conservative Maximum Densities."

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COLONIZATION OF A PREVIOUSLY BARREN STREAM SECTION BY AQUATIC INVERTEBRATES AND TROUT

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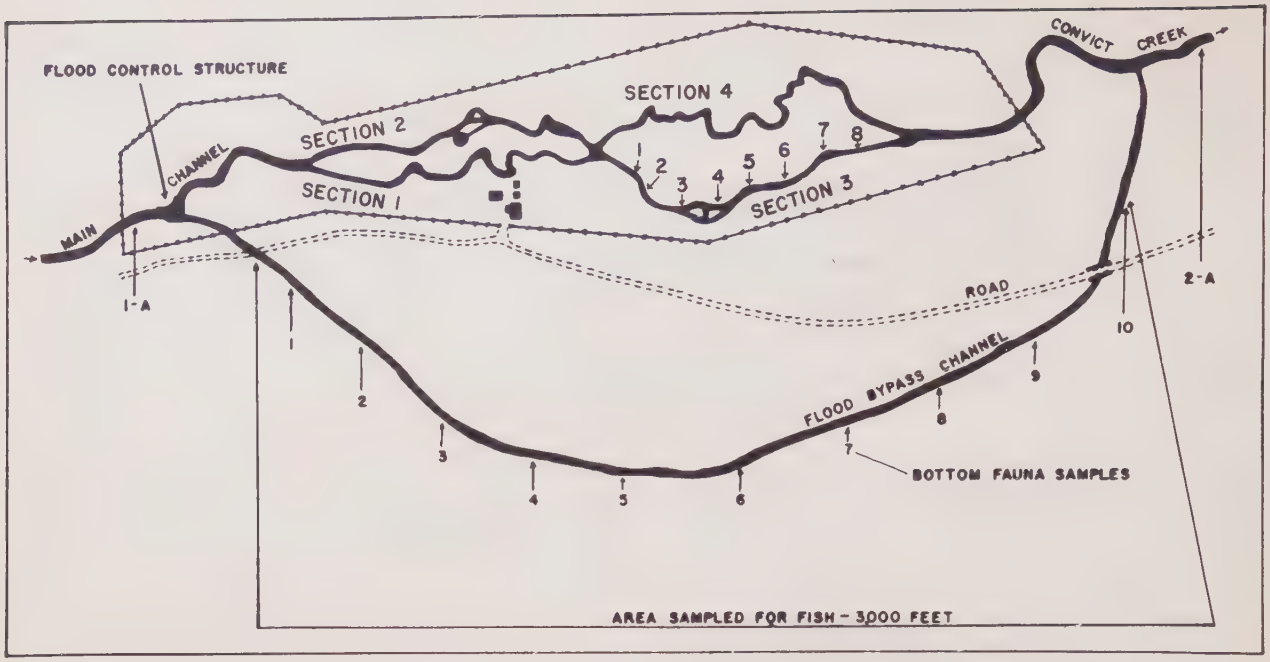
Bishop, California

IN THE SPRING OF 1950, during trout survival studies at the Convict Creek Experiment Station of the U. S. Fish and Wildlife Service in eastern California, there was an excellent opportunity to measure the extent to which aquatic invertebrates and stream-resident brown trout colonized a previously barren stream section.

At the Experiment Station, Convict Creek has been divided into four experimental stream sections which are used in the study of survival of hatchery-reared rainbow trout and stream-resident brown trout. (See figure.) Water-control and screen structures designed to accommodate flows of as much as 100 second feet separate the various sections. Flows that are in excess of this amount are diverted around the experimental area by means of a flood-bypass channel which originates at a flood-control structure near the upstream boundary of the area. Abnormal high water necessitated diversion into the bypass on May 1, 1950, and this flow prevailed until July 26, 1950--a total of 87 days. The bypass channel had been dry for several years prior to this use, and it was therefore easy to determine the extent of colonization of aquatic forms in this newly watered habitat. Accordingly, bottom samples were taken at intervals along the bypass channel immediately prior to cutting off the flow, and comparative bottom samples were taken from section 3 and from the main stem of Convict Creek. All brown trout which had entered the bypass area were recovered alive on the day that this channel was dewatered; and these recoveries were compared with recoveries from stream section 3, which contained an established population of brown trout.

Description of Sampling Areas

The flood-bypass channel has a total length of 3,300 feet, an average width of 10 feet, and a total bottom area of 33,000 square feet. Excavated with a bulldozer, this channel traverses a line of common gradient from its point of origin at the flood-control structure to its confluence with the main channel of Convict Creek, approximately 100 yards below the experimental area. There are no pools in the bypass channel, and it is devoid of shelter, except for that afforded by boulders, particularly in the upper one-third of its course. Stream bank cover is limited to sagebrush and rabbit brush growing on the crests of excavated material but not near the water line. Bottom material consists of boulders, rubble, and large gravel. Because of the steady gradient of the channel, sandy areas are limited to small pockets on the downstream sides of boulders. As a trout stream, it would be considered poor in contrast to the general character of Convict Creek. Flow into the bypass is controlled by the use of dam boards. During the period of colonization by aquatic forms, there were enough dam boards in place to cause a 2-foot vertical drop of water into the channel. In its terminal section (75 yards), the bypass



Reference map of experimental section of Convict Creek.

divides into a number of small distributaries before entering the main stem of Convict Creek. These distributaries meander through a meadow, and a few eventually reach the main channel over vertical falls as much as 2 feet in height. Because of these falls, upstream movements of small trout into and out of the bypass must be limited.

Experimental stream section 3 was selected for comparison because it contained a natural population of stream-resident brown trout. This section has a total length of 1,306 feet, an average width of 10 feet, and a total bottom area of 13,060 square feet. Section 3 is a natural channel with numerous well-shaded pools. Bank cover consists of willows, birch, and dense grass. Undercut banks are common and afford cover and protection for the trout. Bottom material consists of rubble, gravel, and sand in the bottoms of pools. The gradient is less severe than that in the bypass. Trout are confined in this and the other three sections by means of quarter-inch mesh screens which are inserted in concrete structures. Prior to July 1, 1950, no screens had been installed in any of the sections and the stream-resident brown trout had free movement through the entire area. On July 1, the screens were installed and section 3 was dewatered. All the trout were removed, individually weighed and measured, and returned to the section on July 2, 1950.

Results of Invertebrate Sampling and Trout Census

Aquatic Invertebrates

A series of 10 square-foot stream-bottom samples was taken from the bypass channel at 75-yard intervals, and a series of 8 bottom samples was taken from experimental stream section 3 at 50-yard intervals. Additional samples were taken from Convict Creek above and below the experimental areas (designated as stations 1-A and 2-A). Organisms taken in all of the samples were grouped taxonomically and counted (table 1).

On the basis of composition and average numbers of organisms per sample, there was a high degree of uniformity

TABLE 1.--Numerical comparison of bottom fauna composition in three sampling areas

Group	Bypass Number in 10 samples	Section 3 Number in 8 samples	Stations 1-A, 2-A Number in 2 samples
Ephemerida---	174	159	27
Diptera------	191	34	8
Trichoptera--	36	25	17
Plecoptera---	11	6	2
Hemiptera----	1	0	0
Coleoptera---	8	12	3
Hymenoptera--	2	0	0
Annelidia----	1	8	2
Arachnida----	0	0	1
Hydracarina--	1	2	0
Mollusca-----	12	2	1
Totals-------	437	248	61
Average[1]--	43.7	31.0	30.5

[1] Average number of organisms per square-foot sample.

between samples taken above and below the experimental area and samples taken in experimental section 3. Similarity in species composition was demonstrated in samples taken from the bypass, but--on the average--total numbers exceeded those in samples from experimental section 3 and from stations 1-A and 2-A by 30 percent.

Drift nets fished in the current of Convict Creek during periods of high water failed to reveal the presence of large numbers--or even moderate numbers--of stream-borne aquatic organisms, yet it seems likely that the invasion and establishment of most invertebrates in the bypass resulted from their being carried there by the current--and apparently in considerable numbers. All aquatic life stages of members of the dominant stream groups were found in the bypass, and the composition of life stages there was similar to the composition in areas of the main stream.

Of particular interest was the presence of larvae and pupae of the mountain midge Deuterophlebia nielsoni in several bypass samples. Although the adults of this species are capable of reasonably long flights, they have a nonfeeding life span of only 2 hours and generally are observed near water in the immediate area of emergence. It is improbable that adults propagate the bypass channel directly, and--since the pupae are firmly attached to the substrate--the only other means of establishment would be a downstream drift of larvae through the flood-control structure.

Because of the length of time (87 days) that water was diverted into the bypass, the possibility of egg deposition in its water by adults of other aquatic insects represented cannot be ignored. This possibility may account for insects having short life cycles, but it is inadequate to explain the presence of advanced nymphal stages--particularly those of stoneflies.

Aquatic Vertebrates (Trout)

All trout occupying 3,000 feet of the bypass channel were recovered after the closure of the diversion gates. Water remained in 25 yards of the channel immediately below the point of diversion and in 75 yards above its lower confluence with Convict Creek, but the capture of the few trout in these areas was impractical because of seepage. The area from which trout were recovered from the bypass has been indicated on the reference map. Recoveries of trout from the bypass and from section 3 are compared in table 2.

TABLE 2.--Comparison of trout recoveries in the two sampling areas

Total length in centimeters	Bypass Number of trout	Bypass Percent of total	Section 3 Number of trout	Section 3 Percent of total
5.0 - 6.5	131	58.5	80	21.7
6.6 - 11.2	46	20.5	95	25.8
11.3 - 14.9	38	17.0	125	34.0
15.0 - 17.1	9	4.0	33	9.0
17.2 - Over	0	.0	35	9.5
Totals--	224	100.0	368	100.0

The extent of movement of trout into the bypass is indicated by the number recovered (224) when the channel was drained. On the basis of square feet of bottom area, it is seen that the normal stream population in experimental stream section 3 was 4.6 times as dense as the new colony found in the bypass. In the bypass there was 1 trout per 134 square feet of bottom area, and in experimental stream section 3 there was 1 trout per 29 square feet of bottom area.

The size distributions in table 2 suggest that the bypass was populated with trout mainly as a result of downstream drift, as smaller trout are more susceptible to transportation by current. Upstream migration was possible, but its importance must be discounted in view of the rapid current and falls at the lower end of the channel.

Remarks

Of principal interest in these observations is recognition of the extent to which an aquatic community may develop, over a period of slightly less than 3 months, in an area which had been completely dry for several years. Successive measurements were not made to determine the rate of colonization, and it is possible that complete distribution required considerably less time.

SIZE OF SALMON MIGRANTS FROM BARE LAKE, KODIAK ISLAND

In the summers of 1950 through 1954, Bare Lake, on Kodiak Island, received applications of commercial nitrate and phosphate fertilizers. These applications were made by the U. S. Fish and Wildlife Service as part of a program undertaken to determine whether the fertilization of a fresh-water lake in Alaska would provide a practicable means of increasing the food supplies available to the blueback salmon.

To evaluate the effects of such fertilization upon fish production, the Service has collected and compiled data during the succeeding years. There is now considerable evidence that blueback salmon feeding in Bare Lake have shown improved growth and survival. C. E. Atkinson, chief of the Service's Pacific Salmon Investigations, has recently submitted the following table of measurements taken from salmon migrating downstream:

Year	Number of migrants	Age composition (percentage) 2-yr.	3-yr.	Mean length (mm.)	Mean weight (gm.)
1950	10,199	67	33	72.8	3.31
1951	4,503	23	76	81.8	4.81
1952	8,620	39	60	79.1	4.46
1953	5,058	32	68	90.2	6.54
1954	12,195	86	14	93.7	8.21

The ligament of the oyster has been the subject of detailed study at the Woods Hole Laboratory of the U. S. Fish and Wildlife Service. A rubberlike substance that pushes apart the oyster's valves when tension of the adductor muscle is lessened, this nonliving structure controls the extent to which the valves may open when the mollusk is feeding--and thereby determines the amount of water that may be taken in by the gills. Any study of the rate of feeding of oysters should allow for the fact that in many specimens the valve opening may be impeded by malformation of part of the hinge, by lodging of pebbles or other foreign particles between the beaks, and similar obstructions.

GROWTH OF BROWN TROUT FINGERLINGS ON A DIET FORTIFIED WITH AUREOMYCIN AND THIAMINE HYDROCHLORIDE

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AT MINNESOTA TROUT HATCHERIES in 1952, brown trout (Salmo trutta fario) were fed a diet consisting of 45 percent ground beef spleen and 55 percent dry-cereal mixture. Whole frozen spleen, obtained from a local meat-packing plant, was thawed and ground at the hatchery. To this ground spleen was added a dry-cereal mixture consisting of 22 percent each of soybean meal, cottonseed meal, red-dog wheat flour, and spray-dried skim milk, plus 2 percent salt and 10 percent dried brewer's yeast. The completed food was prepared in the form of semimoist pellets about one-fourth inch in diameter.

As part of a continuing program for the development of better trout diets, a feeding experiment using brown trout fingerlings was conducted to evaluate the effect that adding aureomycin and thiamine hydrochloride to the foregoing diet would have on growth. This feeding experiment was conducted at the St. Paul Fish Hatchery during the period August 18, 1952, to December 18, 1952.

Experimental Procedure

Twelve hatchery troughs were used. These troughs were 14 feet long and 14 inches wide and had 6 inches of water in them. They received water from a natural spring augmented by water from an artesian well. Water temperatures remained within 1° of 50° F. during the experiment.

Three pounds of brown trout having an average weight of 742 to the pound were placed in each of the 12 troughs. These trout had been obtained from a slow-growing lot of fish at the Lanesboro Fish Hatchery. Trout in 4 of the troughs were fed the diet already described and hereafter called the control diet. Trout in another set of 4 troughs were fed the control diet which had been fortified with at least 6.26 grams of aureomycin per 100 pounds of food. Trout in the third set of 4 troughs were fed the control diet which had been fortified with at least 6.26 grams of aureomycin and 10.0 grams of thiamine hydrochloride per 100 pounds of food.

Aureomycin used in this work was in the form of Aurofac 2A, which is guaranteed to contain at least 3.6 grams of pure aureomycin per pound of Aurofac. The thiamine (vitamin B_1) used was chemically pure thiamine hydrochloride.

At the beginning of the experiment, the trout were fed at the rate of 8 percent of their body weight per day. The feeding rate was reduced as the fingerlings increased in size -- the Cortland Feeding Chart was used as a guide -- until at the end of the experiment they received 4.5 percent of their body weight per day. Minimum feeding level for aureomycin was 4.98 milligrams per pound of trout per day at the beginning of the experiment and 2.817 milligrams at its conclusion. Similarly, minimum feeding level for

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Minnesota Department of Conservation, Fisheries Research Investigational Report No. 142.

Growth data for brown trout fingerlings during eight 2-week periods

Diet		Growth period No.-- 1	2	3	4	5	6	7	8	Mean
Control diet.	Percentage of body weight gained per period.	34.6	30.8	29.8	22.5	17.5	21.6	12.5	13.3	22.8
	Conversion ratio.	3.26	3.68	3.95	3.10	4.40	3.57	4.12	4.51	3.82
	Mortalities--	0	4	2	2	0	0	1	0	-----
Control diet fortified with aureomycin.	Percentage of body weight gained per period.	35.0	32.5	24.6	23.8	19.2	23.5	12.5	16.3	23.5
	Conversion ratio.	3.21	3.44	4.58	2.99	3.99	3.26	4.12	3.66	3.66
	Mortalities--	0	9	4	0	1	0	0	0	-----
Control diet fortified with aureomycin plus thiamin.	Percentage of body weight gained per period.	35.8	32.1	25.8	24.6	19.2	22.1	11.7	16.2	23.5
	Conversion ratio.	3.16	3.52	4.39	2.93	3.99	3.44	4.37	3.66	3.68
	Mortalities--	0	7	0	0	1	0	0	0	-----

thiamine hydrochloride was 8.0 milligrams per pound of trout per day at the beginning of the experiment and 4.5 grams at its conclusion.

At the end of each 2-week growth period, the trout in each trough were weighed and enough trout were removed to reduce the weight again to 3.0 pounds. In this removal operation it was assumed that the average weight of the individual trout removed was the same as that of those trout remaining in the trough. The initial number of trout in each trough was determined from weight and sample counts of the lot of fingerlings used. Numbers present at the end of any growth period were determined by subtracting from the initial number the fish previously removed and those found dead in the troughs. Mortality of trout throughout the experiment was low (see table).

Weighing was accomplished by removing the trout from the trough with a small seine and putting them in a rectangular metal basket placed in the trough. The basket was then removed from the trough and allowed to drain from one corner about 20 seconds. In this time most of the free water was drained off. The fish were then poured into a previously weighed pail containing water, care being taken that any water remaining in the basket did not enter the pail. Weighing was done on a Chatillion balance graduated on 0.5 ounce. Weights in ounces were changed to decimal parts of pounds and rounded to the nearest 0.05 pound.

At the end of each 2-week growth period, the following data were compiled for each trough: (1) percentage of body weight gained, (2) amount of food fed, (3) conversion ratio, and (4) natural mortality. Data for the trout receiving the three diets have been summarized in the table, which shows the eight 2-week growth periods.

Conclusions

It will be observed from the table that the percentages of body weight gained per period and the food conversion factors are similar for the trout on the control diet and the trout on diets fortified with aureomycin and aureomycin plus thiamine. Differences were small; to evaluate them, a Chi-square common distribution test was applied to the percentages of body weight gained per period. It is believed that, although the figures used in the Chi-square analysis were percentages, this was a valid procedure because all the percentages were obtained by using the same divisor, 12 pounds.

The Chi-square analysis gave a value of 1.278, which, at 14 degrees of freedom, indicates a Chi-square probability of 0.999. There is, therefore, less than one chance in a hundred that apparent growth differences were real and not due to sampling. It is concluded, therefore, that the growth of the brown trout fingerlings was not increased significantly by addition of the given levels of aureomycin or aureomycin plus thiamine to the control diet described.

LAKE TROUT PRODUCTION ON LAKES HURON, MICHIGAN, AND SUPERIOR

(From a report prepared by Ralph Hile and Howard J. Buettner of the U. S. Fish and Wildlife Service for the 1954 meeting of the Great Lakes Fishery Committee)

Production (thousands of pounds) of lake trout in the upper Great Lakes, 1949 - 1953, and modern "normal" production in the various waters

Lake and state or province	Production in year					Modern normal production[1]
	1949	1950	1951	1952	1953	
Lake Huron						
Michigan	1	(2)	(3)	(4)	(5)	1,685
Ontario[6]	399	416	553	588	344	3,596
Total	400	416	553	588	344	5,281
Lake Michigan						
Michigan	223	25	2	(7)	(8)	2,525
Wisconsin	115	25	7	3	(9)	2,542
Illinois	4	4	2	(5)	(5)	457
Indiana	(5)	(5)	(5)	(5)	(5)	126
Total	342	54	11	3	-----	5,650
Lake Superior						
Michigan	2,181	2,400	2,174	2,074	1,746	2,180
Wisconsin	514	591	504	521	450	533
Minnesota	270	202	233	243	217	336
All U. S. waters	2,966	3,193	2,911	2,838	2,413	3,049
Ontario	1,356	1,506	1,273	1,389	1,371	1,395
All waters	4,322	4,699	4,184	4,227	3,784	4,444

[1] Years on which normal catches are based: Canadian waters of Lake Huron, 1923-1939; U. S. waters of Lake Huron, 1895-1939; Lake Michigan, 1927-1944; Canadian waters of Lake Superior, 1930-1949; U. S. waters of Lake Superior, 1926-1949.

[2] 65 pounds. [3] 25 pounds. [4] 26 pounds. [5] No production.

[6] Includes Huron proper, Georgian Bay, and North Channel.

[7] 418 pounds. [8] 286 pounds. [9] 116 pounds.

CONTROL OF *ULOTHRIX ZONATA* IN CIRCULAR PONDS

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THE ST. CROIX FALLS HATCHERY maintains 12 circular ponds among its facilities for rearing eastern brook trout. Circular ponds are used because of their inherent design for self-cleaning. The smooth, sloping concrete bottom directs the food wastes and excrement toward the center, where they are drawn from the bottom of the pond by suction created by the outer sleeve attached to the outlet pipe. Ponds remain self-cleaning until their surfaces become covered with dense growths of filamentous algae, Ulothrix zonata (Weber and Mohr) Kuetzing 1833. When allowed to grow, the matted filaments of Ulothrix attain lengths of 2 to 3 inches in as many weeks. (See figure 1.) The untidy appearance of such ponds and the self-cleaning action are improved only by removing the Ulothrix. The physical labor involved, however, is excessive, as 36 man-hours per week are required to scrub the 12 ponds in the summer season.

Many anti-fouling copper-compounded paints and rubber-base swimming-pool paints have been applied to the concrete ponds in order to provide a surface on which Ulothrix cannot grow. The paints already tested exhibit only short-term inhibiting qualities and are expensive. Algal growth is retarded in ponds that are thoroughly dried and refilled, but this is inconvenient when ponds are needed to hold fish. There is also danger that dry ponds may crack from the heat of the sun.

Delrad 70 (Rosin amine D acetate 70-percent solution in water) was selected as a possible control agent for Ulothrix zonata because of its control of Pithophora (Lawrence 1954). Laboratory trials further indicated the effectiveness of Delrad in killing many varieties of Spirogyra, Oscillatoria, and other filamentous algal forms. Trials using Delrad in hatchery waters of methyl orange alkalinity 127 parts per million, expressed as $CaCO_3$, indicated that 0.25 to 0.50 part per million active ingredient Delrad killed Ulothrix in 5 to 6 hours at temperatures of 48° to 50° F. with no apparent deleterious effects on brook trout fingerlings. The problem became one of finding a simple automatic method of maintaining in the waters the concentration of Delrad that is required to eradicate the Ulothrix.

Best control was attained by placing 15 grams of Delrad 70, paste form of the algaecide, in a modified piece of pipe (2 inches in diameter) with 1/4-inch mesh screen soldered to the bottom (figure 2). Size of mesh had little effect on the dispersal of the algaecide, but the 1/4-inch mesh remained free of debris longer than smaller mesh. This applicator pipe was suspended by a hook into the water at the pond edge, the open end of the pipe being above the surface (figure 3). The quantity

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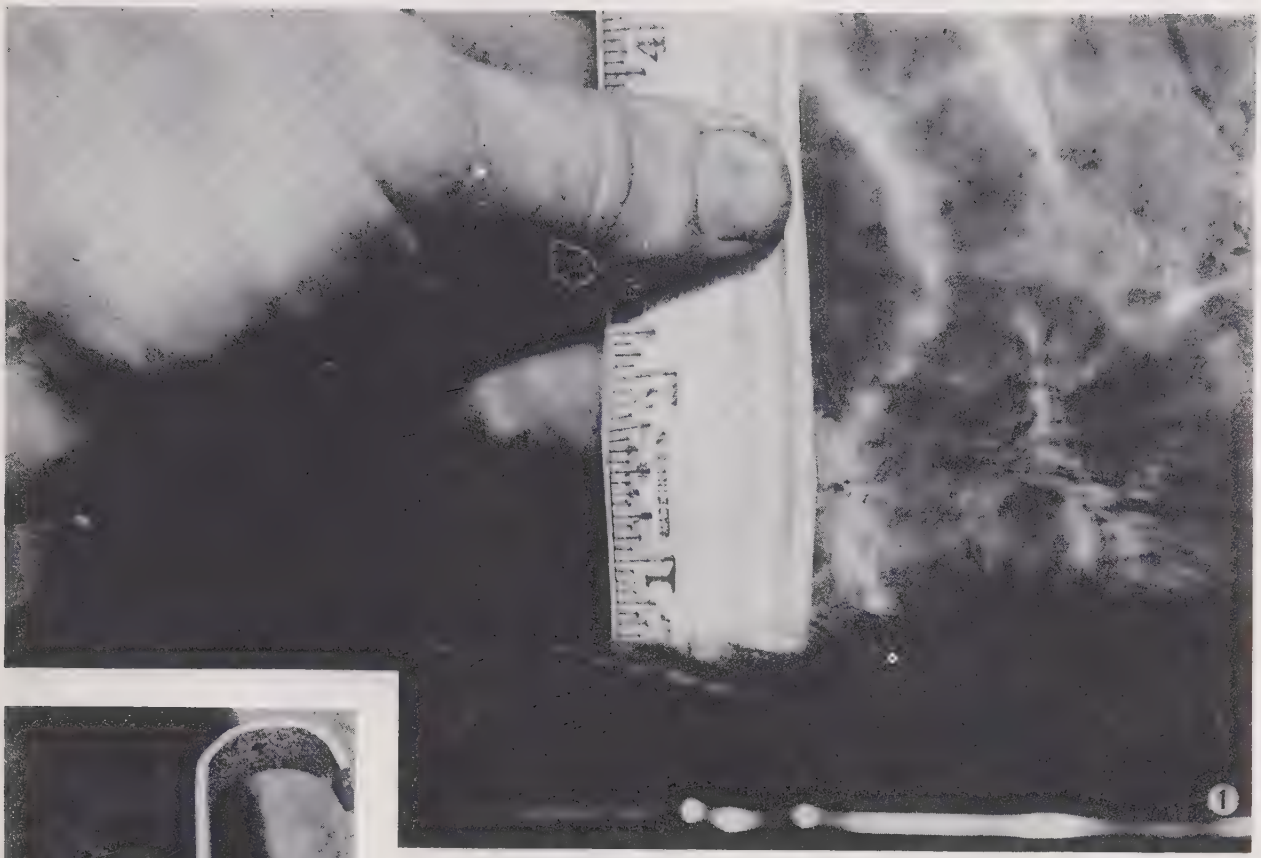
FIGURE 1.--Filaments of the Ulothrix form dense mats on surfaces of circular ponds, thereby impeding self-cleaning action.

FIGURE 2.--Dispenser formed by pipe 2 inches in diameter.

FIGURE 3.--A lightly rounded tablespoonful of Delrad in the dispenser eradicates Ulothrix.



(Photographs
courtesy of
the author)

of Delrad 70 required was based on the computed volume of water for each of the ponds (each 18 feet in diameter) plus the additional inflow of 30 gallons of water per minute over a 5-hour period. Under the described conditions, circulating pond waters evenly distributed the algaecide at the desired rate of approximately 0.5 part per million concentration of active ingredient for 4 to 6 hours.

With further trials, it was found that Delrad 70 placed in the applicator pipe in quantities ranging from 5 to 30 grams killed Ulothrix without harming the trout. The larger quantity of algaecide took longer to dissolve and apparently did not increase the immediate concentration of algaecide in the water. With allowable variations in the dosage of algaecide, it became a simple matter to dispense a lightly rounded tablespoonful or heaping teaspoonful (each approximately 15 grams) of the algaecide per pond on a weekly or monthly basis or as needed. This labor involved only 10 minutes per application.

The Ulothrix declined with successive chemical treatments, but diatoms increased to such an extent that concrete surfaces became coated with a thin film that resembled brown paint. The disadvantage of diatom color was outweighed by the following advantages: (1) Ponds continued to be self-cleaning; (2) Ulothrix was suppressed, even though algaecide treatments were discontinued; (3) dark diatom color seemed to be preferred by the trout; and (4) diatoms were scrubbed from concrete surfaces more easily than the Ulothrix filaments when it became necessary to work in ponds.

A number of experiments were involved in developing a workable algaecide dispenser for circular ponds. Whenever the dispenser is used for the first time at a hatchery or under different water conditions, it is advisable to use the algaecide on only a few trout for the first times. It may be necessary to slow the diffusion process by using a pipe of smaller diameter or to hasten the release of algaecide by submerging the top and bottom of the pipe in the water. The method for control of Ulothrix is successful in saving labor and time in the operation of circular ponds and has potentialities for the control of filamentous algae in conventional raceways.

Acknowledgments

Howard Berquist, Harold Thompson, and Andrew Seed, of the St. Croix Falls hatchery, made observations on the behavior and feeding of trout during the experimental use of the algaecide Delrad.

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TEST OF PLANTING WALLEYE FRY BY PLANE

Most of the season's plants of walleye fry from the U. S. Fish-Cultural Station at Miles City, Montana, were made from the air.

As the plants of walleye fry were to be placed in waters scattered over a large area, distribution by airplane was obviously to be desired if the fry could survive the drop into the water. To discover whether they could survive the shock, a number of fry were put into a nylon stocking and then into a plastic freezer bag that was partly filled with water. When it hit the water the bag literally exploded and thus released the stockingful of fry. This was then recovered and emptied into a tank of water. As these fry were alive 10 days later, the plans for the distribution of the remainder of the walleye fry by airplane were completed.

RAINBOW TROUT MORTALITY AND CARRYING CAPACITY OF A REHABILITATED TROUT LAKE IN MINNESOTA

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THE PRESENT PROGRAM FOR THE REHABILITATION OF SMALL LAKES in northern Minnesota for trout has shown the need for information on carrying capacity of such waters, mortality of trout planted in them, and most suitable stocking rates. The present investigation deals with the fish population of a typical lake that was rehabilitated by means of rotenone poisoning in 1949.

Surprise Lake is a small landlocked lake near Grand Rapids, in the northern part of Minnesota. The lake has an area of 11 acres, a maximum depth of 27 feet, and a thermocline late in summer at a depth of 8 feet, below which there is insufficient oxygen for trout. About 30 percent of the bottom area of the lake lies above the thermocline level. The water is soft (total alkalinity, 15.0 parts per million), brown, and of moderate fertility. There are few aquatic plants. Recorded summer temperatures of the surface water range from 74° to 87° F. and in the thermocline (at 10 feet) from 63° to 74° F.

In the summer of 1949 the lake was poisoned with rotenone after a sample of the fish had been marked for determination of percentage recovery. The total fish population was estimated at 77 pounds per acre, mostly of suckers (Catostomus c. commersoni), perch (Perca flavescens), golden shiners (Notemigonus crysoleucas), and mud minnows (Umbra limi).[1/] In the spring of 1950 the lake was stocked at the rate of 136 trout, or 22.7 pounds of trout, to the acre. In the spring of each of the following years, the lake has been planted with rainbow trout in amounts ranging from 63 to 161 fish, or 4.3 to 17 pounds of fish, per acre. Stocking for the past 3 years is shown in the table. Size of fish stocked has ranged from 6 to 32 to the pound. No natural reproduction of trout is known to occur in the lake.

Late in the summer of 1954 (August 16 through September 27), after sport fishing on the lake had ceased, the lake was intensively netted with six trap nets having 50-foot leads and made of 1-inch bar-measure mesh. In the initial phase of the investigation (August 16 to August 31), a standard experimental gill net with five mesh sizes was also used. No population estimates were attempted during this phase. Twenty-two trout were captured and removed from the lake to provide total-length measurements, scale samples for aging, individual weights, and stomachs for food-habit analysis. Trap-net sets were made in water 4 to 5 feet deep with the top of the lead just below the water surface. With the exception of an occasional perch and sucker, trout were the only fish taken in the nets.

The lake was then trap-netted for an additional 3 weeks. During this phase 53 trout--the figure includes recaptures of marked fish--were taken in 72 trap-net

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1/Appelget, J. G., 1949: Elimination of rough fish from Surprise Lake, Itasca County, Minnesota, and an estimate of the total population. Minn. Fish. Res. Inv. Rep. 89, 4 pp., unpublished.

lifts. After providing additional length measurements and scale samples, the trout were marked by the removal of the pelvic fins and released in the center of the lake. In accordance with the statistical methods of Schnabel (1938) and Schumacher and Eschmeyer (1943), estimates of total size of the population of catchable trout were made. By the method of Schnabel, the total population in the lake was calculated to be 88 fish. To this estimate should be added the 22 fish removed for study, making a total of 110 fish. By the method of Schumacher and Eschmeyer, the population in the lake was estimated at 83 fish plus or minus a standard error of 19 fish. Allowing again for the 22 fish taken for study, the total population was estimated by this method to be 105 fish plus or minus 19. On the basis of average weights of fish of different ages captured and the Schumacher and Eschmeyer population estimate, the trout population per acre was estimated at about 10 catchable-size fish weighing about 3.4 pounds.

Stocking and survival of rainbow trout in Surprise Lake, 1952-54

Year class	Stocking		Survival to fall of 1954			
			Fish recorded		Estimated population	
	Numbers	Pounds	Numbers	Pounds	Numbers	Pounds
1952------	1,504	47	1	3.2	2	6
1953------	1,775	188	16	9.0	27	15
1954------	696	58	45	9.5	76	16

Assuming that the 62 trout taken by netting and later aged were a fair cross section of the total population structure, it is estimated that, of the fish in the lake in the fall of 1954, 72 percent had been planted in the spring of 1954, 26 percent in the spring of 1953, and 2 percent in the spring of 1952. Total mortality for these respective year classes from stocking to the time of netting in the fall of 1954 is estimated at 88.3, 98.3, and 99.8 percent, respectively.

As there was no creel census on this lake, differential causes of mortality cannot be assigned. It might be noted, however, that the lake has moderate fishing pressure, and that Kelley (1953) found in abandoned quarries in central Minnesota a high return to the anglers of stocked catchable rainbow trout during the first season after stocking (at least 50 percent and possibly as high as 90 percent in some quarries). Also, nine snapping turtles weighing about 80 pounds were taken during the netting. Such turtles are known to be fish eaters (Lagler 1945); whether they take trout is uncertain, however, since Alexander (1943)--who found suckers, bullheads, sunfish, and perch in the stomachs of snapping turtles--concluded: "The faster and better game fish are not taken by the snapper in any great amount." H. O. Swenson of the Minnesota Bureau of Fisheries reports that in 1928 he caused a snapping turtle to disgorge seven 6-inch trout that had been planted recently in a stream.

Scale samples and length measurements show that the growth of the trout in Surprise Lake has been rapid. Total length of trout fingerlings that had been stocked in the spring of 1954 ranged from 6.4 to 11.0 inches in the fall of the year. The average weight increase for these fish was from 0.08 to 0.21 pound in about 2 months--an increase more than 50 percent greater than that in Minnesota hatcheries with water at 48° F. Similar rapid growth of stocked trout in rehabilitated lakes has been noted by Westerman (1943) for Michigan and by Johnson for a lake in Wisconsin.[2/]

As has been stated, the standing fish crop of Surprise Lake when poisoned in 1949 was estimated to be 77 pounds per acre and the size of the trout population in the fall of 1954 was about 4 percent of this, or 3.4 pounds per acre. It seems evident that only part of the available food

2/ Johnson, L. D. 1949. Paper presented at the Midwest Wildlife Conference at Madison, Wisconsin, Dec. 15-17. Unpublished.

supply is being utilized by the trout. To check the feeding habits of the trout, the stomachs of 9 trout taken in the nets were examined. Percentages of different foods, by volume, were found to be: insects (mostly Odonata nymphs, Chironomus larvae, and Trichoptera adults), 59.4 percent; small minnows, 27.0 percent; detritus and vegetation, 10.8 percent; and unidentifiable material, 2.7 percent. The fishery literature shows that the staples of this trout diet are similar to those of the fish species that formerly inhabited the lake.

It appears, therefore, that Surprise Lake--and probably similar rehabilitated lakes--have a food supply and a carrying capacity in rainbow trout that are not being utilized fully at present Minnesota rates (about 150 3- to 6-inch fish per acre per year) and that heavier stocking might be expected to produce a larger standing crop and greater yield to the angler. Johnson and Hasler (1954) report a carrying capacity of about 50 pounds of rainbow trout to the acre for small dystrophic lakes in Wisconsin, and studies of trout streams in Minnesota show that carrying capacities of this magnitude in streams are not uncommon. Carrying capacities for warm-water fishes in Minnesota lakes are often several times this amount. It is suggested that, for best management of rehabilitated trout lakes, the original carrying capacity of the lake (as shown by poisoning) be taken into account and the goal for trout be set at a fraction, perhaps half, of the original carrying capacity. In heavily fished trout lakes, several plantings a season may be necessary to obtain full utilization of the environment.

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To determine precisely the growth rate of the redfish on this side of the Atlantic, specimens collected from the same stock every 3 or 4 months were examined at the Woods Hole Laboratory of the U. S. Fish and Wildlife Service. From these collections it was possible to observe the increasing width of a zone of material deposited on the otolith (ear bone). It was established that this slow-growing fish laid down but a single otolith ring per year, and that the older fish grew only about 1 centimeter per year.

AN EPIZOOTIC OF ICHTHYOPHTHIRIASIS AMONG FISHES IN A LARGE RESERVOIR

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EPIZOOTIC INFESTATIONS with the protozoan parasite, Ichthyophthirius multifiliis, among fishes in a large reservoir in the United States have not been reported previously. This paper reports a lethal outbreak of ichthyophthiriasis in Deep Creek Lake, a 3,900-acre impoundment in Garrett County, Maryland, in the spring of 1954. The disease affected chiefly the yellow perch (Perca flavescens) population.

A few dead fish were noticed by local residents as early as mid-April, but it was not until mid-May that the dead fish appeared in numbers sufficient to cause alarm. The situation was then called to the attention of the Maryland Game and Inland Fish Commission, which took steps to have the cause of death ascertained. A sample of fish was taken to the Leetown (Kearneysville, West Virginia) Hatchery, where Dr. S. F. Snieszko identified the infesting organism as Ichthyophthirius multifiliis. He found that the perch were also infested with another protozoan parasite, Trichodina spp., and with a fungus, Saprolegnia. However, the infestations of these organisms were so slight as to be considered of secondary importance as lethal agents. Other fish in this sample--bluegill (Lepomis macrochirus), pickerel (Esox niger), and largemouth bass (Micropterus salmoides)--were not affected.

An estimate of the kill was attempted by the author during a visit to the lake at the end of May. Forty-five stations, more or less evenly divided along the perimeter of the lake, were selected; and at each station all dead perch which could be seen on 300 feet of beach were counted. The distribution indicated that the kill was spread throughout the lake: one station held no dead fish, but the other stations had dead fish ranging in number to 103. The average was 29. If the sampling were assumed to be representative, the total number of carcasses on the 60 miles of shore would be 28,000.

The figure of 28,000 dead fish, however, does not adequately describe the total kill. There was evidence that many bodies had been covered by shore gravels and that there had been heavy scavenging by birds and mammals; there were also several reports that cottage owners had attempted to clean the beaches. For these reasons it seems safe to guess that less than half of the washed-ashore fish were seen, and the estimate conservatively could be doubled to 56,000 beached fish. Moreover, not all the dead fish were washed on shore: 8 of the stations were at steep banks that provided very little beach for the collection of fish; many dying fish were undoubtedly eaten by larger fish; and casual counts of dead perch lying on the bottom in shallow water, compared with the numbers of fish floating in the immediate vicinity, indicated that there were many more "sinkers" than "floaters." A guess would be 1 fish washed ashore to 2 sunk or eaten by other fish. Speculating in this manner, we arrive at 170,000 as the estimate of the kill of fish by the end of May. This is 7.5 times the total number of perch taken by the lake's anglers in 1951, 1952, and 1953.

Of the dead fish seen at the 45 sampling stations, only 4 were not yellow perch, but these fish had been dead so long as to preclude identifying the cause of death. All newly dead perch showed the characteristic blotches of ichthyophthiriasis. Examinations of a few fishermen's creels during this visit indicated that rock bass (Ambloplites rupestris), smallmouth bass (Micropterus dolomieui), pumpkinseeds (Lepomis gibbosus), and golden shiners (Notemigonus crysoleucas) were not affected. These creels also contained a few uninfected yellow perch.

Dying perch were observed near the surface everywhere in the lake and, in the shallow places, near the bottom. The fish appeared to be in a stupor, except for a listless movement of their tails, and made no attempt to flee when approached. None of them exhibited the scratching movements symptomatic of the disease. It was easy to catch, by hand, these dying fish--which then expired almost immediately.

On a visit to the lake in mid-June, the epizootic was seen to have subsided considerably, although dying perch were still scattered about the lake. No attempt to estimate the kill was made, as a rising water level during the preceding week had carried away most of the carcasses or caused them to rot beyond recognition. By the end of June, according to correspondents, the disease had run its course.

Trap-netting in mid-June disclosed that the brown bullhead (Ameiurus nebulosus) population was very much afflicted with columnaris, and the rock bass with an unidentified copepod. Examination (with hand lens) of non-perch species in the trap nets revealed what appeared to be occasional Ichthyophthirius on largemouth bass, rock bass, and golden shiners, but the disease in these species apparently did not reach such great proportions.

Deep Creek Lake is a 3,900-acre hydroelectric impoundment of cool, very soft water at an altitude of 2,462 feet in the Allegheny Mountains. At full pool, it has a maximum depth of 70 feet, an average depth of 30 feet, and a shoreline of 62 miles. An average annual-maximum drawdown of 14 feet occurs in November or December. A poorly defined thermocline is found at about 30 feet, below which the oxygen falls to less than 4 parts per million. The pH is about 7. The water is moderately clear, Secchi-disc readings of 8 feet being the rule. Vegetation is sparse. In addition to the fish already mentioned, the lake contains rainbow trout (Salmo gairdneri), black crappie (Pomoxis nigro-maculatus), and white suckers (Catostomus commersoni). Gizzard shad (Dorosoma cepedianum) and white bass (Morone chrysops) have been planted recently.

FINGERLINGS FROM EARLY SPAWNING SALMON

The experimental work on the use of gonadotrophins to speed up maturation of salmon continued at the Salmon-Cultural Laboratory of the U. S. Fish and Wildlife Service in 1954. This series of tests at the Entiat, Washington, laboratory proved that gelatin was an effective agent for use in delaying absorption, but the premature aging continued to result in the death of precocious fish prior to spawning.

Nevertheless, for the first time at this laboratory, R. E. Burrows was able to report that eggs spawned a month prior to normal had survived to the fingerling stage.

"Viable eggs were produced," writes Burrows, "from fish spawned one month ahead of normal. These eggs, although but one-half normal size, developed into fingerling fish. Losses were abnormally high in this group, however, amounting to 76 percent in the egg stage, 1 percent in the fry, and 9 percent in the fingerling. . . . This early spawning group resulted from adults that received 6 chum salmon pituitaries combined with gelatin."

SELECTIVE POISONING OF GIZZARD SHAD WITH ROTENONE

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KENTUCKY BIOLOGISTS, during the last 5 years, have noticed and discussed the extreme sensitivity of gizzard shad, Dorosoma cepedianum, to rotenone. In population studies on Kentucky, Cumberland, Herrington, and Dewey Lakes, it was noted that shad were nearly always the first to show distress after rotenone application, and that other shad swimming into the area days later--long after the toxicity of the water had fallen below the lethal point for other species of fish--would die.

Rotenone treatment to kill shad without harming other fishes was first attempted in Kentucky on Kentucky Lake in the summer of 1950. In this experiment the idea was to use rotenone at standard concentrations directly on the surfacing schools of shad. It was reasoned that 1 pound of rotenone per surface acre in pelagic areas would form a lethal concentration in the top few feet of water, where the shad were observed, and would dilute to a nonlethal concentration as it sank into deeper water where the other species normally would be found. This work was done in the middle of the day during the summer, when shad were at the surface in large schools.

Although this experiment was successful in that practically no other fishes were killed, the time consumed and the effort expended in spraying individual schools of shad were not justified by the relatively small percentage of the total shad population killed. It was thought that aerial spraying of surface-feeding shad was feasible, but this possibility was not followed up at that time.

In the summer of 1954, a serious shad problem was found to exist in Carpenter Lake, a 70-acre State-owned impoundment located 9 miles northeast of Owensboro, Kentucky. It was decided to attempt to poison shad selectively with a low concentration of rotenone. It was reasoned that if a large portion of the shad population could be eliminated, better living conditions might be created for the other species in the lake. These species included

One concentration of shad killed by selective poisoning in Carpenter Lake.

(Photo by Homer Bow, Evansville Courier)

largemouth bass, bluegill, black and white crappies, green sunfish, longear sunfish, warmouth, bullhead, drum, and several species of minnows.

Final plans were made to treat the lake in October 1954. At the time of treatment, the water had a temperature of 65° F., a pH of 7.4, and a total alkalinity of 60 parts per million. The depth averaged 5 feet; the maximum was 11 feet.

It was decided to treat the area with a concentration of 0.1 part per million and add more rotenone, if needed, until a shad kill was achieved. A mixture of 5 percent powdered rotenone was sprayed over the lake surface with a gasoline-powered centrifugal pump operated from an outboard motorboat. An attempt was made to control the spray so as to get not more than 0.10 part per million in the shallow areas and at least 0.10 part per million in the deeper areas.

Shad began showing signs of distress within 15 minutes after each area was sprayed. No additional rotenone was needed.

The shad died within an hour after treatment, except for a few individuals which were still surfacing at nightfall. All activity was over by the next morning.

Shad did not float to the surface in great numbers until the second day after treatment. Twenty-seven homes on the lake shore made removal of the shad mandatory.

As about 50 pounds of shad per acre were expected, only 2 men, the biologist and assistant, were present. When it became apparent that shad were present in much greater numbers than had been anticipated, 2 laborers had to be hired.

The containers used to hold recovered shad were filled and weighed at the beginning of the removal program. After that the containers were counted as the shad were dumped into the burial holes.

In 7 days, 14,050 pounds of shad were picked up and buried, and an estimated 6,000 pounds decomposed and sank before being picked up. Nine 8- to 10-inch bass and one hundred and thirty 5- to 6-inch bass were killed. Thirty-five 6- to 7-inch bluegill, one thousand 1- to 4-inch bluegill, and four 6- to 8-inch bullheads were also killed. No minnows, drum, or crappie were recovered. It is believed that the bass, bluegill, and bullheads killed were in shallow areas where the concentration of rotenone became too high in spite of the precautions taken.

One area was resprayed 3 days later to determine whether any shad had survived the original treatment. No further shad kill was observed; however, time alone will tell whether the total population of shad was eliminated.

Within 3 days a definite increase in fishing success was noted, bass activity around the bank of the lake being quite noticeable.

Two hundred and eighty-five pounds of shad per acre were removed from this lake with the loss of less than one pound of game and pan fish per acre. The project met with approval and enthusiasm of the local fishermen and of residents around the lake, most of whom are fishermen.

Kentucky is at present planning selective poisoning of shad in a 900-acre lake in eastern Kentucky and possibly one or two other smaller lakes.

The task of censusing the California gray whale was one of the assignments of the South Pacific Fishery Investigations of the U. S. Fish and Wildlife Service during the spring of 1955. A cow and calf seen at Conception Bay, on the eastern side of Baja California, represented the first record of calving on that side of the gulf and indicated continued expansion of the population. Observations to date have pointed to the occurrence of a biennial cycle in calving: only cows without calves have been seen mating.

SPORT-FISHING TRENDS IN MINNESOTA

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RELIABLE RECORDS OF SPORT FISHING prior to extensive stocking of inland lakes and recent heavy fishing pressure are scarce. Recently such a record--a log of the Monmouth-Miltona Fishing Club of Alexandria, Minnesota, for the years 1894-97--has become available. Catch data in this log throw some interesting sidelights on the sport-fishing trends in Minnesota.

The 15 members of this club fished in 7 typical hard-water morainic lakes of west-central Minnesota. The bulk of the fishing was on Lake Miltona (5,322 acres), Lake Ida (4,643 acres), and Spring Lake (145 acres)--all in Douglas County. The members were, evidently, expert fishermen who preferred to catch largemouth and smallmouth bass. By mutual agreement, the members of the club recorded the catch of each fishing trip, the number of fishermen in each party, and the lake fished. For the summers of 1894-97, there are recorded 1,424 angler-trips, on which 17,198 fish were caught. This provided an average catch of 12.1 fish per angler-trip.

The table has been prepared to show the percentage composition of the 1894-97 catch from the 7 lakes. For general comparison, the percentage composition of the summer catch in 1952 for 6 similar--but not the same--lakes in western Minnesota is also included. Average catch rate from these lakes in 1952 was 2.4 fish per fisherman-trip.

The high proportion of black basses (largemouth and smallmouth) in the early catches is especially interesting because it verifies reports and more general information on the early sport-fishing importance of these species. Of the total black bass catch, about 40 percent consisted of smallmouth bass and the remainder of largemouth bass. Appreciable numbers of walleyes, now fairly common in almost all the lakes of the region, were taken from only one lake--Lake Irene. This lake, strangely enough, now has principally a bass population.

Percentage composition of summer angling catch

Species	1894-97 (seven lakes)	1952 (six lakes)
Black basses---	47.80	2.3
Rock bass------	28.70	3.2
Walleyes-------	7.40	11.2
Northern pike--	3.20	14.6
Crappies-------	6.90	12.1
Sunfishes------	6.00	47.6
Bullheads------	.05	4.6
Perch----------	0	4.6

The low proportion of black bass shown in the 1952 catch figures is fairly representative of catch from Minnesota fishing waters, even though lake surveys often show that large bass populations are present. Probably several factors are involved in the present small bass harvest. There is anglers' preference: black bass now are generally held in lower esteem by the angling public than walleyes or northern pike. About half of Minnesota fishing water is being managed primarily for walleyes, and this species has been

elevated recently to the rank of official "State Fish." Also, the low bass catch in 1952 probably reflects fishing regulations in effect during that time: a season from about June 20 to November 30 for bass and from about May 15 to February 15 for other species. It is well known that bass are taken more readily in spring than during the summer.

Other factors that probably affected bass catch include the introduction of German carp into southern Minnesota about 1880, and the extensive and often indiscriminate stocking of walleye pike in the period 1910-40. It is likely that walleye populations have sometimes been built up at the expense of bass populations.

The lakes which had large black bass catches in 1894-97 also had high catches of rock bass. Lake Irene, where walleyes predominated, had a low rock bass catch. Today the rock bass is usually retained by anglers but is regarded as a second-rate sport fish, mostly because it is often grubby. It is widely distributed but is usually not taken in abundance.

Higher proportions of other species in present-day catches represent a more complete utilization of fish populations, a condition which has developed with increased angling pressure. It might be pointed out that the number of nonresident licensed anglers in Minnesota has increased from 4,689 in 1911 to 311,428 in 1953, and the number of resident licensed anglers has increased from 361,171 in 1927 to 980,380 in 1953.

Northern pike, once regarded as a "snake" hardly fit to be eaten, now makes up about one-third of the poundage of fish taken from census lakes. Crappies and sunfish, once considered boys' fishes, are now sporting favorites. Even perch and bullheads are being taken in increasing numbers, mostly by visitors from other States where they have long been fished.

The divergence in catch per trip--from 12.1 fish in 1894-97 to 2.4 in 1952--may not be so great as it appears, since expert fishermen are being compared with a cross section of the present angling public. But it seems safe to say that fishing was really better 60 years ago. However, the yield of sport fish per acre is almost certainly higher now because of more complete utilization of fish populations. It is of interest to note also that even in 1894-97 there were times when fishing trips yielded no fish.

AN OUTBREAK OF "RED TIDE" IN THE LABORATORY

To provide clearer understanding of the rapid reproduction by means of which a small outbreak of "red tide" can develop under favorable conditions into an extensive kill of fish and aquatic life, an explosive bloom of Gymnodinium brevis was artificially atimulated, under the direction of William B. Wilson, Gulf Fishery Investigations, in the Ft. Myers, Florida, laboratory of the U. S. Fish and Wildlife Service.

Cultures of Gymnodinium brevis at concentrations of 3,000,000 cells per liter were used to kill a number of fish experimentally, and the fish so killed were permitted to remain in the open cultures (beakers) for about 2 hours after death. When they were removed from the beakers the fish were gently squeezed so that the body fluids would drop back into the culture. This stimulated the dinoflagellate to make such rapid division that it effected a threefold increase in 4 days--a concentration that had not been attained previously in laboratory cultures.

The findings of this experiment confirmed those of earlier experiments in which increased growth of the microorganism was secured by using sterile juices that had been extracted from the muscles of fresh fish.

A METHOD OF NUMBERING DEPTH GRADUATIONS ON HAND LINES

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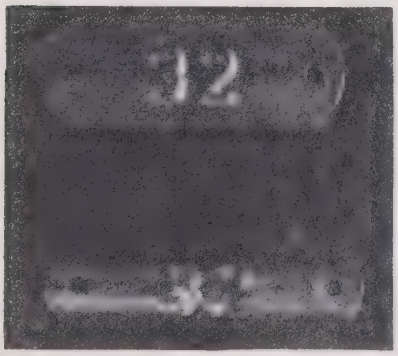
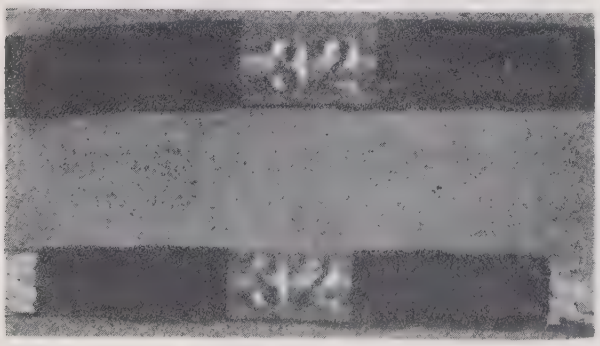
THIS METHOD OF NUMBERING DEPTH GRADUATIONS was originally used on the underwater cable of an electric thermometer. The electric cable could not readily be marked by any of the well-known depth-coding systems. The present system has been used on a braided cotton line and on a plastic line. Essentially, a number is embossed on a metal strip, and this strip is bent to the shape of the line and attached to it by means of water-resistant tape.

Embossed numbers are easy to read, and there is probably less chance for error in reading them than when depths are coded--especially when lines are used by inexperienced personnel.

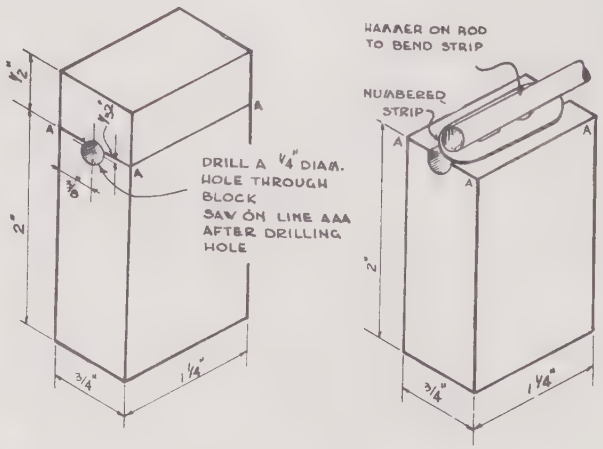




Photographs by W. E. Clark, staff photographer of Illinois Natural History Survey

The markers for the lines mentioned were numbered on an embossing press, or labeling machine, which stamped a figure 1/4 inch high on an aluminum strip, 1/2-inch by 1/64-inch. This machine was equipped with "high relief" type. To prevent jagged breaks in the metal when the strips were bent to fit the lines, the downward movement of the embossing-press handle was made 1 to 1-1/2 inches short of a normal stroke. This resulted in "low relief" embossing--and less stretching of the metal. These presses are available as "floor" models and as portable "hand" models, the latter being, of course, much less expensive.

Bending the embossed strip to fit halfway around a line requires preparation of a grooved wooden block. The block should be of soft wood, such as ponderosa pine. A hole 1/4 inch in diameter is drilled through the block, and the end of the block is sawed off so that the saw passes 1/32 inch above the centerline of the hole.



With the block clamped in a vise (to prevent the wood from splitting), a few light blows with a hammer on a round rod or drill shank will force the flat metal strip to assume the shape of the groove. Occasionally only one edge of the strip enters the groove as a result of this hammering. The other edge will then project slightly above the surface of the block and should be bent against the rod before the strip is lifted from the groove. Forcing the strip into the groove does not tend to flatten the embossed figures.

The hole drilled for the groove and the rod used in bending the markers should be of the same diameter as the line that is to be graduated.

Two turns of plastic electrical tape--a tape selected after a number of careful tests, as well as consultation with electricians, to determine the brand that would provide the best adhesion under these circumstances--proved satisfactory for holding the markers to the lines. Recent examination of lines in use 2 to 3 years, however, indicates that this tape may be somewhat better suited for use on rubber-covered cable and cotton sash cord than on plastic clothesline. The tape used on the plastic line has not unwrapped, and the markers have not shifted from their original positions, but the tape appears somewhat stretched and the markers are slightly loose. Possibly the tape has stretched because the 3/16-inch plastic line is capable of sharp bends at the ends of the markers. Neither the electric cable (diameter, 9/32 inch) nor the sash cord (diameter, 5/16 inch) can be bent so sharply as the plastic line.

TREATMENT OF SOFT SHELL IN TROUT EGGS

Use of gentian violet (aniline violet) has proved effective in checking soft shell and preventing the growth of fungus on trout eggs at the Klamath (Oregon) Hatchery. Dr. H. J. Rayner of the Oregon State Game Commission has prepared a brief account of the treatments tried and the results obtained during experimental work undertaken at this hatchery in an effort to eliminate premature hatching.

"Eight lots of 500 eggs each were treated in staggered pairs in a single trough series with acriflavine (1:2,000 for 25 minutes), gentian violet (1:18,000 for 5 minutes), and malachite green (1:14,000 for 30 seconds) every 48 hours over a period of 47 days, beginning with green eggs. Two lots of eggs received no treatment with dye.

"The results of the use of gentian violet indicate its value at the Klamath Hatchery. Until further studies indicate otherwise, the dye should be used every 48 hours. The table does not show mortalities resulting from soft eggs, but since the mortalities are large, the advantages of using gentian violet are obvious.

"If eggs are to be eyed at the Klamath Hatchery, the use of gentian violet will be necessary until the cause of soft shell has been determined and eliminated."

Lot number	Treatment	Results	
		Number of dead eggs	Occurrence of soft shell (A) or fungus (B)
1	None----------	132	A, B
5	---do.----------	192	A
2	Malachite green--	50	A
6	---do.----------	106	B
3	Gentian violet---	21	----------
7	---do.----------	7	----------
4	Acriflavine------	250	B
8	---do.----------	207	B

A CORE SAMPLER FOR OBTAINING SAMPLES OF BOTTOM MUDS

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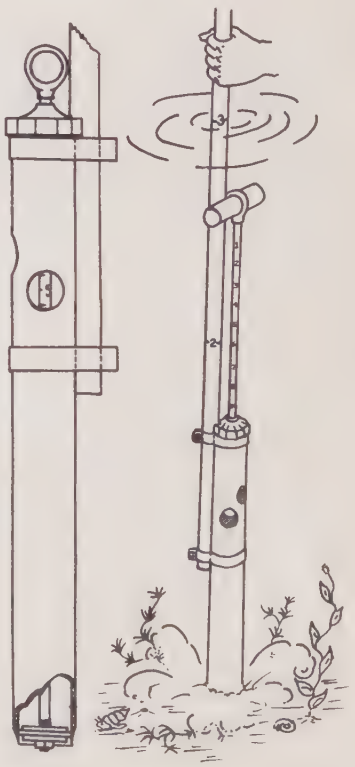
ANALYSIS OF THE BOTTOM MUD is usually essential in studying the chemistry of small bodies of water. The bottom mud-and-water interface is usually the point of greatest biological activity. Many nutrients, as phosphorus, are available through chemical exchange with organic and colloidal materials at this interface.

The chemical analysis of bottom mud is no more accurate than the method by which the sample was collected, and a quantitative sampling method is needed for study of this material. A core sampler probably provides the best method for getting reliable results in sampling bottom material.

For sampling bottom mud in shallow waters, a core sampler was made from an automobile tire pump. (See figure.) The foot of the pump was removed from barrel and plunger. Several holes were bored in the upper part of the barrel to allow free flow of water as a sample is taken. The lower end of the barrel was honed to a sharp cutting edge. A rod cut to the length adequate for the working depth desired was fastened to the barrel with two universal clamps and graduated in inches to measure the depth of sampling. The plunger also was graduated so that any desired depth of sample could be separated for analysis.

Samples are obtained at the desired water depth by ramming the sampler down to the clay sub-bottom, thus sealing the sample in the barrel. A twisting motion helps to remove the sampler from the bottom. After the sample is obtained, bottom ooze is removed by pushing the plunger to the more solid material, turning the sampler on its side, and drawing the plunger back slowly. The ooze will run from the holes in the barrel and can be caught in a jar. The rest of the sample is removed by pushing in the plunger. The graduated plunger rod serves to aliquot portions of the sample according to the desired depth.

This device defines the depth of sampling more precisely than other methods used. It is especially useful in determining the amount of deposition and removal of nutrients from bottom muds. Ooze, usually lost in other sampling methods, is easily retained in this sampling device. Use of this method is limited to bottom materials of fine consistency. Rocks or other large, hard objects cause errors of an indeterminate nature. The sampler works best on bottom muds where ooze is shallow.



Two views of the core sampler: at left, a cut-away view of the plunger mechanism; at right, a demonstration of the working principle.

(Courtesy the author)

REPRINT

WEED CONTROL IN FARM PONDS

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The problems of weed control can be greatly reduced in farm ponds, if the pond edge is deepened so there are no water areas shallower than 18 inches and the recommended fertilization program is followed from the time the pond is first filled with water. Since these practices are not followed in many ponds, and often even in well managed ponds some weeds may appear, other control measures are necessary to eliminate the water weeds.

It is generally recognized by fisheries workers that there are five major groups of aquatic weeds which must be controlled in a fish pond, if such a pond is to produce good fishing. These groups are as follows: filamentous algae, submerged weeds, emergent weeds, marginal weeds, and floating weeds.

Summarized below are methods for controlling weeds in each of these groups, which have been selected from several references.

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Type Growth	Name of Weed	Control Measures[1]		
FILAMENTOUS ALGAE		COPPER SULPHATE	DELRAD[2]	SODIUM ARSENITE
	Spirogyra	1 ppm.	0.2 ppm.	4 ppm. (As_2O_3)
	Oedogonium	1 "	0.2 "	4 " "
	Pithophora	--------	0.2 "	4 " "
	Hydrodictyon	1 "	0.2 "	4 " "
	Chara	1 "	0.2 "	----------
SUBMERGED WEEDS		SODIUM ARSENITE	WINTER FERTILIZATION	0.25% 2,4-D OIL SPRAY
	Najas	4 ppm. (As_2O_3)	"	----------
	Elodea	4 " "	"	----------
	Coontail	4 " "	"	----------
	Milfoil	4 " "	"	----------
	Bladderwort	4 " "	"	----------
	Potamogeton	4 " "	"	----------
	Parrots feathers	4 " "	"	" on emergent growth

See footnotes at end of table.

Type Growth	Name of Weed	Control Measures[1]		
EMERGENT WEEDS		0.25% 2,4-D OIL SPRAY	CUTTING PLUS FERTILIZATION[3]	
	Water lilies	"	"	
	Lotus	"	"	
	Spatterdock	"	"	
	Watershield	----------	"	Partial draining to dry
	Pennywort	"	"	roots.
MARGINAL WEEDS		0.25% 2,4-D OIL SPRAY	PERIODIC CUTTING	
	Primrose willow	"	"	
	Sedges	"	"	
	Smartweeds	"	"	
	Cattails	"	"	(4/)
	Arrowhead	"	"	0.1% 2,4-D water spray
	Pickerel weeds	"	"	" " "
	Bulrush	"	"	
	Spike rush	"	"	
	Knot grass	"	"	
	Southern water-grass	Draining plus 0.25% 2,4-D oil spray		
	Needle rush	"	"	
FLOATING WEEDS		0.25% 2,4-D OIL SPRAY	HAND REMOVAL	0.1% 2,4-D WATER SPRAY
	Duck weeds	"	"	----------
	Hyacinths	"	"	"

1/ Repeated applications of a chemical at the recommended rate may have to be made to control the filamentous algae.

2/ Delrad, same as Rosin Amine D Acetate, manufactured by the Hercules Powder Company, Wilmington, Delaware.

3/ Three to five cuttings during the first summer may be necessary.

4/ For cattails one may use 0.5% 2,4-D + 0.1% Tide + 1.0% TCA + water spray.

NOTE: When using herbicide sprays, respray applications are applied whenever sufficient regrowth appears.

HERBICIDE DILUTION TABLE

Compound	% Active ingredient	% Spray solution	Mixtures Units/5 gals.	Units/100 gals.
Ester form 2,4-D	37 - 40	0.10	1/10 pt.	1 qt.
Ester form 2,4-D	37 - 40	0.25	1/4 pt.	2½ qts.
Ester form 2,4-D	37 - 40	0.5	1/2 pt.	5 qts.
Ester form 2,4,5-T	40	0.25	1/4 pt.	2½ qts.
T.C.A.	90	1.00	1/20 lb.	1.1 lbs.
Tide	----------	0.10	1/10 pt.	1 qt.

AMOUNT OF CHEMICAL REQUIRED TO GIVE A DEFINITE CONCENTRATION IN POND WATER

Chemical	% Active ingredient	Concentration ppm.	Amount per acre foot[1]
COPPER SULPHATE	100	1.0	2.7 lbs.
DELRAD 50-S	50	0.2	1.0 lbs.
DELRAD 70	70	0.2	0.75 lbs.
SODIUM ARSENITE			
ATLAS "A", 4 lbs./gal. (As_2O_3)		4.0	3.0 gals.
PENITE 6, 9.5 " " "		4.0	5 qts.

NOTE: 1 ppm. of a chemical in pond water is 2.7 lbs. of chemical per acre foot.
1 acre foot is the volume of water in an area of 1 acre and 1 foot deep.

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3. Cutting plus fertilization:
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Fishermen have long argued about the use that the marlin makes of its bill when taking prey. When the John R. Manning, research vessel of the U. S. Fish and Wildlife Service, returned to her Pearl Harbor base in the spring of 1955, the catch included a 1,500-pound white marlin. The marlin's stomach contained a freshly killed yellowfin tuna--5 feet in length and weighing 157 pounds--which had been speared twice through the body before being swallowed.

CLEARING HOUSE

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Atlanta 3, Georgia.

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